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Important Progress in Brick Pavement Design

Twenty-one years ago, in his "Handbook of Cost Data," the editor said: "For street pavements the bricks or blocks are laid on edge (making a brick pavement 4 ins. thick), but for sidewalks they are usually laid flatwise. I believe that in residence streets the bricks should usually be laid flatwise for true economy's sake." The last sentence was italicised.

It should be remembered that the design of a brick pavement was at first merely a modification of the design of a stone block pavement, brick being substituted for stone. Even the thick "sand cushion" of the old stone block pavement was retained for brick pavements. In an editorial article in Engineering and Contracting, Sept. 26, 1906, we said: "Formerly it was the custom to lay the (asphalt) blocks on edge, following the precedent of stone block and brick pavement construction; but within recent years the asphalt blocks have been laid flatwise, thus forming a wearing coat of asphalt blocks 3 ins. thick, each block being 3x5x 12 ins. The old theory that a block pavement of any kind should be made of blocks set on edge is thus utterly overthrown, and it is not unreasonable to expect to see the time when paving bricks will also be laid flatwise, thus effecting a great economy in material. . . . Coming now to the method of laying asphalt blocks in New York City, we find another departure from precedent in that the venerable sand cushion has been abandoned. Of course a base of concrete is provided in the usual manner, but, instead of laying a sand cushion on this base, it is now the practice to spread a thin coat of cement mortar on which the asphalt blocks are laid."

But not till many years later did the "monolithic brick pavement" come into use.

In this issue will be found an excellent report on tests of thin brick pavements made by engineers of the Bureau of Public Roads. The report indorses a brick pavement thickness of 2.5 ins. for heavy traffic and 2 in. for light traffic. On the basis of 1925 shipments of paving brick, amounting to more than 10,000,000 sq. yds., the use of 2.5 in. brick would result in saving at least $1,500,000 annually.

In another article in this issue an interesting account is given of the relaying of a worn brick pavement. The original pavement was of brick set on edge. The bricks were taken up and relaid flatwise, and it was found unnecessary to buy any new bricks.

In this connection it may be interesting to add that the editor first thought of laying brick flatwise when he saw an old brick pavement that had been worn so thin in spots that it was less than 2 ins. thick, yet even where the worn bricks were only 1.5 ins. thick none had broken under the impact of heavily loaded truck wheels. This pavement was on East Avenue, Rochester, N. Y., a heavily travelled street. The bricks were of poor quality, very soft, and had worn badly into pot holes, yet, even so, they were not broken under the wheel sledging that they had received. Hence it seemed evident that if a good quality of paving brick were laid flatwise, they would not be broken by the wheels. And since the wear upon good brick, even under iron-tires and horses' calks is very slow, it seemed to follow that flat-laid brick would show a very long life. This reasoning proved to be correct.

At about the same time the editor made another suggestion that has yet to be given a trial. He had observed that in Buffalo, N. Y., one of the best asphalt pavements had been laid on an old macadam pavement. This suggested the laying of new macadam as a base

for brick and asphalt pavements wherever it could be laid cheaper than concrete.

If one-tenth as much experimenting were carried on in pavement design and construction as in building construction, we should witness far more radical advances in the art of constructing highways. The reason why relatively few experiments are made in pavement design appears to be that if a contractor makes them, he can not profit from them except through a patent, and if he secures a patent, most engineers are inclined not to specify his pavement. If a city engineer is inclined to experiment, he must secure an appropriation for the purpose; and this is usually very difficult, for city councils are not much given to that sort of thing.

State and federal highway engineers are engaging more and more in experimental work. We shall also witness more experimentation on the part of manufacturers of products and machines used in highway construction.

It is fortunate, indeed, that we have 48 states in which independent investigations and experiments may proceed. It would be more fortunate if we had 480 states, provided every one of them had its highway research laboratories and field experiment stations; for there is just as much opporunity to improve highways as to improve any other device by which man ministers to his economic needs.

H. P. Gillette

Why Road "Boosting" Should Not Cease

In round numbers the following sums were collected in taxes from the users of motor vehicles in 1925:

Licenses and motor car plates	$260,000,000
Tax on gasoline	150,000,000
State and local property taxes on motor vehicles	150,000,000
Federal government internal revenue tax on motor vehicles	140,000,000
Total	$700,000,000

As the total annual expenditure for road construction and maintenance is only $1,000,000,000, it is evident that the users of motor vehicles are paying 70 per cent of the bill directly.

The federal government collected $140,000,000 from the tax on automobiles manufactured in 1925, and returned only $100,000,000 to the automobile owners in the form of state aid in road building. So Uncle Sam can hardly be said to have been cheating himself in his federal aid program.

During the past decade Uncle Sam has appropriated only $600,000,000 for road building, yet a cry has been recently raised against even so modest an aid as this to the improvement of the public highways. As an asset in case of war our highways are already worth far more than their entire cost, to which total Uncle Sam has contributed only a pittance.

Should a great railway strike occur, as it may one of these days, the improved roads of America will be found to be priceless.

Yet barely seven per cent of our total road mileage has thus far been paved with macadam or better pavement. And we are progressing altogether too slowly in paving the mileage that must be paved before we can point with real pride to our highway system.

Of our 3,000,000 miles of roads, only about 16 per cent are "surfaced" with gravel, or sand-clay, or paving of some sort. It would probably pay well to surface 50 per cent of the total mileage with gravel or better. In any event, road improvement is scarcely more than well begun; and the annual expenditures for the improvement should be several fold what they now are.

Don't forget that 40 per cent of the annual expenditure for highway work by states goes for maintenance, leaving only 60 per cent for new construction. There are no data showing what the corresponding percentages are for county and township road work, but it may be an even higher percentage than 40 for maintenance.

It will be many a year before propaganda for road improvement can safely be dropped. Should not the American Road Builders' Association become far more active than it has been in "boosting" the good road along?

"Reclamation and Farm Engineering" Purchased by Engineering and Contracting Publishing Co.

The publishers of ROADS AND STREETS announce they have purchased "Reclamation and Farm Engineering," the national magazine of the land reclamation industry, and will consolidate it with Engineering and Contracting.

Formerly "Reclamation and Farm Engineering" was owned by 40 representative contractors and engineers interested in drainage projects, flood control, levee work, dredging, irrigation and reclamation. The construction plant owned by this group of 40 represents an investment of more than $30,000,000 and their annual operations are many times that amount.

This industry, which is to receive increased attention by Engineering and Contracting, is already a highly developed field, requiring in

excess of $150,000,000 worth of equipment. It is represented by a national organization—The National Drainage Congress—and, until now, has supported a live and growing publication of its own. Other organizations active in this field are the "Drainage and Levee Contractors' Association" and the "Western States Reclamation Association."

This field will be served even more effectively by Engineering and Contracting, for the broader contacts and interests of this magazine will undeniably broaden and extend the interests of the reclamation industry. A section in each issue of Engineering and Contracting will be headed "Drainage and Irrigation" and will contain articles of special interest to this field.

The magazine policies indorsed for years by the National Drainage Congress will be adhered to as closely as possible by Engineering and Contracting. The secretary of the Congress, C. R. Thomas, was formerly on the editorial staff of Engineering and Contracting, and he has, with other officers of the Congress, approved this consolidation.

Engineering and Contracting now has considerably over 14,000 paid subscribers with no signs of let-up in the remarkable volume of new paid subscriptions coming in each month.

Economic Loss from Muddy Roads

Editorial in Des Moines (Ia.) Capital

Canning factories in various sections of Iowa were forced to suspend operation for several days this week for the reason that they were temporarily cut off from their source of supply. Heavy rains and muddy roads made it impossible for the truck farmers in these communities to reach their market. The Capital has seen no estimate of the loss to sweet corn and tomato growers, but it is reasonable to assume that there was a loss of large proportions, for the raw materials used by canning factories are highly perishable. A loss to the canning industry and its workers must also be added, and the bill as a whole must be charged to the account of mud.

Where farmers depend chiefly on a home market of this nature the economic need for all-weather roads is readily apparent. The same principle is involved, with a difference only in degree, in every rural community. It could easily happen, and it undoubtedly has happened many times, that individual farmers miss the best opportunities for advantageous selling on account of isolation caused by rain and mud.

No matter how far Iowa may go along other lines in promoting more uniform prosperity for agriculture, the economic strength of the state will not be fully developed until a state-wide system of all-weather roads is provided.

Surface Finish of Concrete Bridge

The Bridge Department of the California Highway Commission considers the surface finish of their reinforced concrete bridges of paramount importance. The surfaces to which the finish is applied are the under and outside of the exterior girders, the cantilever overhang of the deck, the curbs and rails, columns and caps, arch rings and the exposed surfaces of the abutments and walls. We are indebted to the Concrete Highway Magazine for the following details of how this particular feature was handled on the recently completed Charley Creek bridge, a one-arch span 154 ft. long.

As soon as the forms were stripped, a cement grout was applied to the surfaces with a paint brush. The grout consisted of two parts of portland cement to one part of fine sand to which was added calcium chloride equal in amount to 5 per cent of the portland cement in the mixture. The calcium chloride was added to hasten the setting of the grout. The time for setting of the grout depended upon weather conditions, varying from 5 hours in warm weather to 48 hours in rainy weather. For the finish of the hand rail and curb, pure hydrated lime was added to the cement grout to obtain a lighter color for the rail, making the rail more visible at night and at the same time adding to the appearance of the structure. After the mortar had sufficiently set, the grout coat was thoroughly wet with water and rubbed with a carborundum stone until a lather was formed and the air pockets filled. It was then brushed out to a smooth and uniform surface with a wet brush. Redwood was used for the forms of the hand rail. It was found this material had no tendency to warp. The surface of the rail needed very little working over for the purpose of removing form marks and projections, and its appearance and the small cost of finishing fully justified the use of the redwood for the forms.

Demand for Local City Managers.—In a recent address before the International City Managers' Association, Dr. L. D. White of the Department of Political Science at the University of Chicago, stated that the demand for local city managers was shown in the figures that the first managers were 56 per cent outsiders and the second appointments were 38 per cent outsiders. On arriving at these results 905 appointments were taken as a basis. The average term of office for 839 managers in 355 cities is about two years and six months, he continued, which does not compare favorably with the four-year term of most mayors.

Large Projects in Highway Field

A $32,000,000 County Road Improvement Program

The highway advisory committee appointed by the Commissioners of Cook County, Illinois, to study the problems of traffic congestion in county highways has recommended an expenditure of $32,000,000 for the construction of new highways, the widening of existing roads and the surfacing of various strategically located dirt roads. The program includes:

1. Widening to 40 ft. of 74.6 miles of existing highways. 2. Construction of 63 new stretches of 20-ft. highway, totaling 249.5 miles. 3. Construction of 48.3 miles of new 40-ft. roads at important outlet points. 4. Widening to 40 ft. of 51.5 miles of present highway by the building of shoulders and the construction of new bridges. Of the total cost Cook County would pay $21,000,000. The county already has $6,000,000 for this work, and a bond issue for $15,000,000 more will be voted on at election on Nov. 2.

Road Bond Issues in Wisconsin Counties

Marathon County and Waukesha County, Wisconsin, vote Nov. 2 on $3,000,000 and $1,050,000 bond issues for constructing concrete roads. Langlade County also will vote Nov. 2 on a $1,000,000 issue for highways. Other Wisconsin counties that either have voted or are contemplating bond issues for road purposes include the following: Dane County has a bond issue of $2,500,000 for the building of 159.5 miles of concrete with a total estimated cost of $4,123,280. Vernon county has raised $400,000 in bond issue funds for the construction of 63 miles of crushed limestone surfacing at a total cost of $985,000. Crawford County is building 83 miles of crushed limestone surfacing out of a bond issue of $280,000 and a total estimated cost of $830,000. Portage County is building 50 miles of concrete at a total estimated cost of $1,500,000 with a bond issue of $965,000. Waupaca County is building 40 miles of concrete and 70 miles of gravel surfacing at a total estimated cost of $1,891,000 and with a bond issue of $1,200,000. Marathon County voters voted on Oct. 5 on a five-year construction program calling for the building of 140 miles of concrete to cost about $4,200,000. It is proposed to issue $3,000,000 in bonds. Clark County is considering a program of 100 miles of concrete.

Toll Road Proposed in New Jersey

A syndicate is considering constructing a concrete toll road between Camden and Atlantic City, paralleling the famous White Horse pike. The plan as tentatively reported contemplates six 20-ft. roadways. These roadways would be separated by 3-ft. grass plots. Three of them would be used for eastbound and three for westbound traffic. It is planned to confine the use of the outside roadway to trucks, the middle one to traffic of moderate speed, and the inside roadway to those who desire to proceed at maximum speed. It is announced, too, if the highway is constructed, that the intersections with other roads will be bridged or tunneled.

Ohio County to Vote on $8,000,000 Bond Issue

Cuyahoga County, Ohio, will vote Nov. 2 on issuing $8,181,000 of bonds for paving various roads.

Iowa County Votes on $1,100,000 Bond Issue

Cedar County, Iowa, will vote next month on a bond issue for $1,129,000 for constructing 35 miles of paved roads and 137 miles of graveled roads. In addition to the above sum $375,000 will be available from the development fund of the state highway commission.

Oklahoma County Issues $1,000,000 of Bonds

The commissioners of Payne County, Oklahoma, have provided for the issuance of $1,000,000 of bonds for road purposes. The state will provide a like amount.

American Bidders on $50,000,000 Cuban Job

Bids for the $50,000,000 central highway were opened Sept. 28 at Havana, Cuba. In all 14 bids were received, only two, however, covering the building of the entire system of 500 miles, The Foundation Co., New York city, and Warren Bros. Co., Boston, Mass., offered to build the entire road.

Texas County Proposes $3,000,000 Bond Issue

Navarro County, Texas, proposes a $3,000,000 bond issue for paving about 110 miles of highway.

Large Road Jobs Let Recently

Foulkes Construction Co., Terre Haute, Ind., at about $720,000 for constructing 27 miles of 16 ft. concrete pavement for State Highway Department of Kentucky—Harrison Engineering & Contracting Co., Springfield, Ill., at $752,000 for 35 miles of pavement for Illinois State Division of Highways—William C. Horn Co., Athens, Pa., at $647,117 for grading and draining of 98,171 ft. of highway in Clinton County, Pennsylvania.

Reconstructing Old Brick Pavement

How Old Pavement on Sand Base With Sand Filler Was Reinforced

By G. A. McCLELLAN
Asphalt Sales Department, The Texas Co.

Elizabeth City, Pasquotank County, N. C., a town of slightly more than 10,000 population, is engaged in the construction of a paving program of somewhat unusual interest. Prior to 1914 there were laid some 150,000 yd. of vitrified brick pavement upon the natural base, which is composed of fine sand. A sand filler was used in this work. These pavements gave excellent service for years but have become rough through the penetration of water to the base and consequent subsidence in pockets. The streets are being resurfaced in the following manner:

The old bricks are removed and stacked on the curbs.

The sand base is reshaped, adding sand where necessary and rolled firm with a 5-ton roller.

The bricks are relaid with the 3-in. dimension vertical instead of the 4-in. as formerly thereby increasing the area covered by an amount more than sufficient to make up the loss in bats and culls.

The surface is then rolled with a 5-ton roller sufficiently to insure evenness and a firm bed in the sand.

An asphalt filler is then squeegeed into the joints with an excess to cover the surface, using from 12 to 15 lb. filler per square yard of surface. Texaco 30-40 penetration asphalt is being used.

The surface is then covered with coase sand and opened to traffic.

The result is a smooth surface apparently the equal of any new pavement as in spite of the age and rough treatment the bricks are not badly spalled or broken.

The average elevation of Elizabeth City is from 3 to 5 ft. and the sand soil is at least several feet deep.

Relaying Old 3 in. by 4 in. by 8½ in. Brick on Natural Sand Base. Note Roller Conveyor for Carrying Brick to Paver

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Michigan Road Convention and Show.—The annual convention and show of the Michigan Association of Road Commissioners and Engineers will be held Oct. 26-29 at Detroit, Mich. An exhibition of road building machinery, equipment and materials will be held in connection with the convention. J. Miller Smith, 3900 St. Clair Ave., Detroit, Mich., is manager of the show.

Trend of Concrete Pavement Design by Years

The trend of concrete pavement design since 1921 toward the thickened-edge type is shown by the accompanying tabulation of Federal-Aid projects made by the U. S. Bureau of Public Roads. The table shows that prior to 1921 all projects submitted were of the thin-edge or uniform-thickness design. In that year the swing toward the thickened-edge section began, and this type has grown in favor steadily. In 1925, the 9-6-9 pavements predominated, although there were many 8-6-8 projects and several with a uniform thickness of 7 or 8 in.

This tabulation, made last April, brings out clearly the change that has taken place in the shape of concrete pavements since the plans for the first Federal-Aid pavement were received in 1917.

Federal-Aid Roads Total 52,526 Miles

Federal-aid roads brought to completion during the fiscal year ending June 30, 1926, amounted to 10,628.3 miles, according to the Bureau of Public Roads. This brings the total mileage of completed Federal-aid roads to 52,526 miles. The new fiscal year was begun with 14,355.1 miles under construction and 2,483 miles approved for construction. There is every indication that progress will equal that of the preceding year.

All Federal-aid funds are being expended in cooperation with the States in the construction of the Federal-aid highway system consisting of 180,000 miles of the most important interstate roads in the country. Provision for the continuation of the work through the fiscal year 1929 was recently made when Congress authorized $75,000,000 for each of the fiscal years 1928 and 1929.

The Trend of Concrete Pavement Design by Years

(Tabulation by U. S. Bureau of Public Roads. Based on Federal-Aid Projects)

Pavement Thickness (Inches)			Number of Projects Submitted by the 48 States by Years								
Edge	Center	Edge	1917	1918	1919	1920	1921	1922	1923	1924	1925
5	5	5	...	1	...	1	2	1	...	...	...
6	6	6	2	3	3	24	24	49	10	4	3
7	7	7	1	11	17	31	22	80	70	33	47
7½	7½	7½	2	4	17	31	21	30	9	1	...
8	8	8	4	17	68	90	78	85	61	51	44
9	9	9	...	1	13	9	9	8	8	...	...
10	10	10	...	...	5	5	5	2	2	...	1
12	12	12	...	...	...	...	...	...	2	...	1
5	6	5	...	...	1	11	3	1	...	...	...
5	7	5	4	10	7	4	...	3	...	...	...
6	7	6	...	1	9	17	8	39	25	...	...
6	8	6	4	13	92	60	56	71	16	25	9
7	8	7	1	11	65	55	23	24	18	...	...
7	9	7	...	...	1	2	...	2	4	...	...
8	10	8	...	...	...	...	...	1	1	...	...
7	5	7	...	...	...	...	...	1	...	...	...
7	6	7	...	...	...	...	...	1	23	38	43
7½	5½	7½	...	...	...	...	...	...	...	...	15
7½	6	7½	...	...	...	...	...	...	...	12	...
8	5	8	...	...	...	...	...	...	...	4	...
8	6	8	...	...	...	...	1	8	17	21	72
8	6½	8	...	...	...	...	...	...	...	...	4
8	7	8	...	...	...	...	...	...	3	25	33
9	5	9	...	...	...	...	...	...	...	2	1
9	6	9	...	...	...	...	3	...	55	180	160
9	6½	9	...	...	...	...	...	...	...	22	34
9	7	9	...	...	...	...	...	9	6	38	49
10	7	10	...	...	...	...	...	2	1	5	3
10	8	10	...	...	...	...	...	1	3	9	3
12	6	12	...	...	...	...	...	...	...	...	1
Total thin edge or uniform			18	72	298	340	251	396	126	114	105
Total thickened edge.....			0	0	0	0	4	122	108	356	418

Thin Brick Pavements Tested

Results of Accelerated Traffic Tests and Field Studies by U. S. Bureau of Public Roads Reported in September Public Roads

By L. W. TELLER and J. T. PAULS

Engineer of Tests and Associate Highway Engineer, U. S. Bureau of Public Roads

There has been manifest lately a growing belief among engineers that brick less than 4 in. in thickness may properly be used in the construction of brick pavements. Advocates of the thinner brick have contended that the 4-in. depth is unnecessary, and that brick of 3-in. thickness or even less would give equally satisfactory results, and the extensive and satisfactory use of 3½ and even 3-in. brick in some parts of the country has apparently lent support to the contention.

If such a reduction in thickness can be made without impairing the service value of the pavement, and if the manufacture of the thinner brick is practicable, the resulting economy in the construction of brick surfaces would doubtless be very considerable; and the question is one which merits thorough investigation on that account. If, as experience has apparently demonstrated, the 3½ and 3 in. thickness can be employed successfully, the investigation should confirm that fact and go further to the extent of ascertaining the least thickness practicable from the points of view of manufacture, service, and cost.

Recognizing the importance of the question the Bureau of Public Roads has undertaken to conduct such an investigation, in the course of which it has made a field study of the service behavior of brick pavements in which brick of less than 4-in. thickness have been used, and concurrently an accelerated traffic test, at Arlington, Va., on sections of pavement built of brick of different thicknesses and a series of laboratory tests on the brick used to determine their quality. Several plants manufacturing brick of less than 3-in. thickness have also been visited to determine the attitude of the industry toward the use of the thinner brick and to ascertain if their manufacture presents any particular difficulties.

Conclusions Indicated by the Investigation.—The several parts of the investigation have now been completed and the analysis of the data obtained seem to warrant certain conclusions, among which the more important are:

1. That 2½-in. brick of the quality used in the Arlington traffic tests, when properly supported, will prove satisfactory for pavements carrying the heavier types of traffic.

2. That brick of 2-in. thickness, when properly supported and of the quality used in the tests, will be adequate for pavements on streets carrying the lighter types of traffic.

3. That a bedding course of plain sand is more effective in reducing breakage of brick than a cement-sand bedding course, the breakage being much less on the former than the latter. The depth of the sand bedding course should not greatly exceed ¾ in. Increasing the depth tends to produce roughness in the pavement.

4. That cobbling of the brick is greatly increased as the spacing between bricks is increased.

5. That the use of excessive quantities of asphalt filler is a common and serious fault in construction, unnecessarily increasing the cost and resulting in a condition which impairs both the appearance and the serviceability of the pavement.

6. That base construction of other than the rigid type may in many cases prove entirely satisfactory. Macadam bases and those constructed of certain types of natural earth appear to be suitable when the local conditions are such that these types of construction maintain their stability throughout the year.

7. That no difference in the base construction is necessary for the different thicknesses of brick.

The Accelerated Traffic Tests. — The accelerated traffic tests have been carried on at the Arlington Experiment Farm, Arlington, Va., during the last several months. Their object was to obtain data on the relative resistance to heavy-truck traffic of paving brick of the several thicknesses, and every effort was made, therefore, to eliminate all other variable factors which might influence the results of the tests, the only exception being the use of the two kinds of bedding course. Because of the opportunity afforded by the test to study the relative merits of the plain sand and cement-sand bedding, it was decided to include this feature, and accordingly the pavement as laid includes duplicate sections

of each thickness of brick, one on each of the two types of bedding.

In order to minimize the possibility of a variation in the quality of the brick used, they were all obtained from one manufacturer, and all are of the vertical-fiber, plain wire-cut, lugless type, 8½ in. long and 4 in. wide, the depths for the several sections being 2, 2½, 3, 3½, and 4 in.

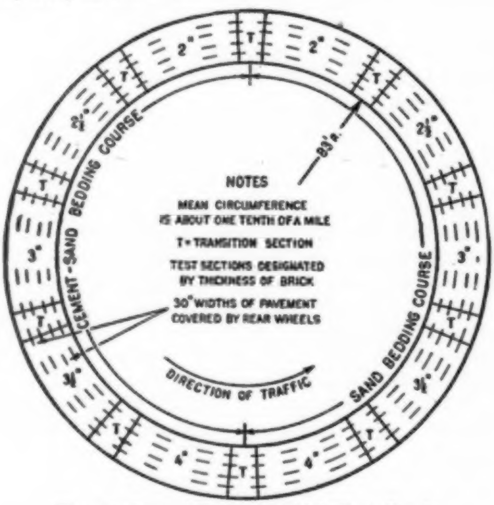


Fig. 1—General Plan of Brick Test Track

A circular concrete base, which formerly had served in tests of bituminous pavements, was available and was used as a base for the brick sections. This base has a mean circumference of about 540 ft., is 13 ft. wide, and at the beginning of these tests was in perfect condition.

For the purpose of the brick test this circular base was divided symmetrically into 10 equal sections. On one-half of the circle the plain sand bedding course was laid to a thickness of ¾ in.; on the other half a 1:4 cement-sand course of the same thickness was used. On each type of bedding five test sections were constructed, one of each thickness of paving brick. Each section was about 45 ft. long and between them the change of ½ in. in surface elevation made necessary by the change in thickness of brick was made in a transition section about 10 ft. long.

This change in elevation was accomplished by adjusting the thickness of the bedding course over a length of about 3 ft. in the center of the transition section, the bedding for this distance being stiffened by the addition of a small quantity of Portland cement. The general plan of the test track and the relative position of the various sections are shown in Fig. 1.

On account of the difference in circumference between the inside and outside edges of the track, it was necessary to give special attention to the manner in which the brick were laid around the circle; and it was decided that the best method would be to lay the brick in a series of short tangents and to join these tangents with "Dutchmen." In the track when completed there was one "Dutchman" in the center of each test section and another in each transition section; and in this way a uniform width of joints was maintained throughout the entire pavement.

After the brick were laid the pavement was rolled with a 3-ton tandem roller, and bricks which appeared to be damp were dried with a portable kerosene torch. This was followed by culling, after which the joints were filled with a squeegee coat of asphalt of 32 penetration, applied at a temperature of 375° to 400° F. The pavement was constructed late in November and on account of the low temperature considerably more asphalt adhered to the surface of the pavement than was desirable. Better filling of the joints would have resulted if higher air temperature had prevailed. A light coat of sand followed the asphalt and another rolling completed the construction of the test pavement. All work was done by a contractor thoroughly familiar with brick pavement construction.

Table I—Loading Program for the Two Phases of the Accelerated Traffic Test

FIRST PHASE

Rated load	Maximum wheel load	Tire size	Load per inch of tire width	Number of trips over each test section
Tons	*Pounds*	*Inches*	*Pounds*	
3	5,800	40 by 10	580	10,000
5	7,750	40 by 12	646	10,000
7½	10,570	40 by 12	881	20,000

SECOND PHASE

Rated load	Maximum wheel load	Tire size	Load per inch of tire width	Chains			Number of trips over each test section
				Diameter	Height above tire	Number per wheel	
Tons	*Pounds*	*Inches*	*Pounds*	*Inch*	*Inches*		
3	5,800	40 by 10	580	½	1⅛	7	10,000
5	7,750	40 by 12	646	½	1⅛	8	10,000
7½	10,570	40 by 12	881	½	1⅛	8	2,200

Before traffic was applied the various sections were marked off with radial painted lines, and longitudinal traffic lines were also painted on the surface in order that the truck wheels might be confined to a path 30 in. wide and thus accelerate the test.

The general plan was to apply 3-ton, 5-ton, and 7½-ton motor-truck loads a definite number of times on each test section and to observe the results. The first phase consisted of the application of these loads with motor trucks equipped with solid rubber tires in good condition. In the second phase the trucks were equipped with heavy nonskid chains on

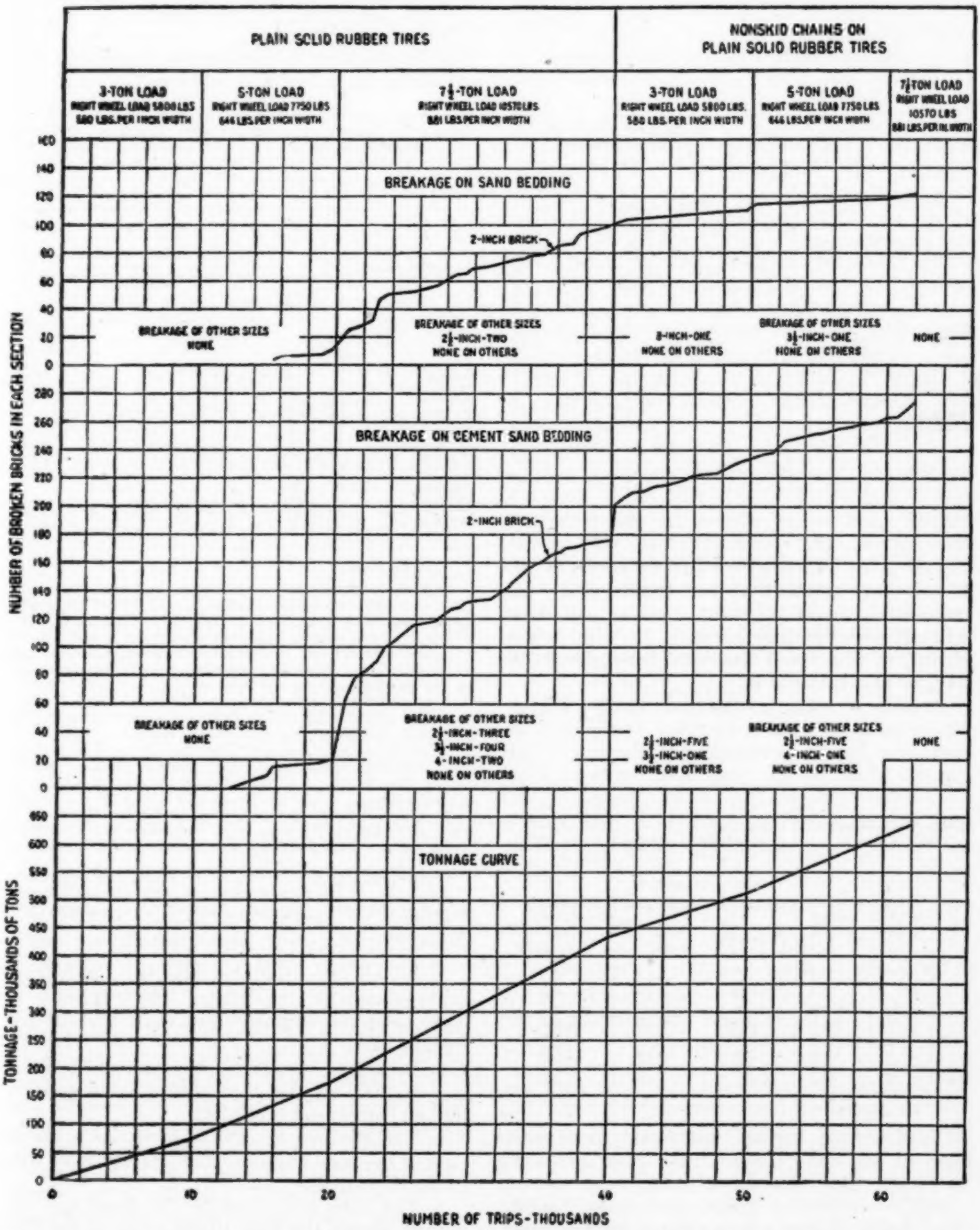


Fig. 2—Results of the Accelerated Traffic Test as Measured by the Number of Brick in the 30-in. Wheel Strips of Each Section Broken Transversely Under Each Load in the Two Phases of the Test; and Curve Showing Tonnage to Which Brick Were Subjected

the rear wheels. The details of the loading program for the two phases of the test are given in Table I.

The base of the test track was originally constructed with superelevation for a speed of 9 miles per hour. It was thought that this speed was too low for representative traffic, and during the tests without chains a speed of 12 miles per hour was maintained. This

Table II—Percentage of Total Number of Brick in the Two Wheel Strips of Each Section, Broken Transversely Under Each Load

Tire condition	Number of trips	Rated load	Thickness of brick: 2-inch, Sand bed	2-inch, Cement-sand bed	2½-inch, Sand bed	2½-inch, Cement-sand bed	3-inch, Sand bed	3-inch, Cement-sand bed	3½-inch, Sand bed	3½-inch, Cement-sand bed	4-inch, Sand bed	4-inch, Cement-sand bed
		Tons	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Plain solid tires	10,000	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10,000	5	1.6	2.1	.0	.0	.0	.0	.0	.0	.0	.0
	10,000	7½	5.6	11.8	.2	.3	.0	.0	.0	.4	.0	.2
	10,000	7½	3.5	4.6	.0	.0	.0	.0	.0	.0	.0	.0
Total			10.7	18.5	.2	.3	.0	.0	.0	.4	.0	.2
With nonskid chains	10,000	3	1.0	6.0	.0	.5	.3	.0	.0	.1	.0	.0
	10,000	5	.5	3.1	.0	.5	.0	.0	.1	.0	.0	.1
	2,200	7½	.4	1.1	.0	.0	.0	.0	.0	.0	.0	.0
Total			1.9	10.2	.0	1.0	.3	.0	.1	.1	.0	.1

caused a difference in pressure under the two rear wheels, the effect of which will be discussed later. During the second phase of the test it was found that the trucks could not maintain a speed of over 9 miles per hour without overheating because of the heavy chains, so this speed was used throughout this part of the traffic test.

Results of the Accelerated Traffic Test.—The results of the accelerated traffic test as measured by the percentage of the total number of brick in the two 30-in. wheel strips

Table III—Results of Physical Tests on Brick Used in Test Pavement at Arlington Experimental Farm, Va.

Brick thickness	Rattler loss by weight	Modulus of rupture: Tested flat	Modulus of rupture: Tested on edge	Crushing strength on edge
Inches	*Per cent*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*
2	22.8	2,088	1,991	10,240
2½	18.8	2,461	2,197	12,530
3	19.0	2,115	1,964	10,770
3½	17.0	2,233	2,146	10,916
4	16.8	2,117	1,998	10,850

of each section, broken transversely under each load in the two phases of the test, as shown in Table II. The same data expressed in numbers of broken brick, graphically for the 2-in. brick and in tabular form for the other thicknesses, are shown in Fig. 2. These are the data from the traffic test. The results of the physical tests of the brick and the compression tests made on brick taken from the pavement after the completion of the traffic tests are shown in Tables III and IV, respectively.

From the study of the graphs in Fig. 2 it will be seen that:

1. Practically all transverse breakage occurred in the 2-in. brick sections.

Table IV—Results of Compression Tests on Different Sizes of Brick in Various Conditions Taken From Test Pavement After Completion of All Traffic

Condition of cobbling	Brick thickness	Average crushing strength on edge (pounds per square inch): Not broken transversely	Traffic stage in which transverse break occurred[1]: A	B	C	D	E	F
	Inches							
Minimum	2	8,370		6,090		10,980	9,170	9,240
Average	2	8,490	7,550	6,260	8,290	6,740		9,570
Maximum	2	7,490	7,820	6,220	7,920	5,770		
Minimum	2½	9,840						
Average	2½	9,240		9,970	9,340	10,810	11,610	
Maximum	2½	8,300			7,270	9,790		
Minimum	3	10,110						
Average	3	8,540						
Maximum	3	8,180						
Minimum	3½	9,860						
Average	3½	9,810			8,150		9,940	
Maximum	3½	6,200				10,120		
Minimum	4	11,090						
Average	4	9,980			9,530		8,620	
Maximum	4	10,730						

[1]Traffic stages.

A. Includes 10,000 trips with 3-ton load and plain solid tires (in which no breaks occurred) and 10,000 trips with 5-ton load and plain solid tires. Breaks under this traffic are indicated in the photographs by a solid circle.

B. Includes A plus 10,000 trips with 7½-ton load and plain solid tires. Breaks under this traffic are indicated in the photographs by an open circle.

C. Includes A and B plus 10,000 trips with 7½-ton load and plain solid tires. Breaks under this traffic are indicated in the photographs by a triangle.

D. Includes A, B, and C plus 10,000 trips wth 3-ton load and plan solid tires with nonskid chains. Breaks under this traffic are indicated in the photographs by a single line.

E. Includes A, B, C and D plus 10,000 trips with 5-ton load and plain solid tires with nonskid chains. Breaks under this traffic are indicated in the photographs by a cross.

F. Includes A, B, C, D and E plus 2,200 trips with 7½-ton load and plain solid tires with nonskid chains. Breaks under this traffic are indicated in the photographs by an open square.

2. Within the limits of the test, resistance to breakage by the 2½-in. brick appears to have been but slightly less than that of the thicker brick.

3. Breakage in sections laid on sand bedding is less than half of that occurring in sections laid on cement-sand bedding.

4. The greatest amount of breakage occurred during the application of the 7½-ton load with plain solid tires.

5. The greatest increase in breakage occurred during the first 10,000 trips of the 7½-ton, plain-solid-tired traffic.

6. The rate of breakage greatly decreased

under the traffic following completion of the 7½-ton, plain-solid-tired traffic.

The high resistance to breakage shown by the 2½-in. brick was one of the important results obtained from this test. The slightly better quality indicated by the physical tests can only partially explain the remarkable strength of this brick under severe traffic conditions.

The marked contrast in breakage occurring on the two types of bedding course strikingly demonstrates the superiority of the plain sand over the cement-sand bedding, at least for the heavy-traffic pavements.

The higher rate of breakage which occurred during the early traffic, as shown in Table II and Fig. 2, is probably explained by variation in the quality of the brick. It is probable that there were in each section certain brick slightly warped or of poorer grade, and these, breaking under the lighter loads, would tend to increase the early rate of breakage.

The greater breakage occurring under the outer wheels in the tests made with plain solid tires is shown by Table V. This is the condition previously referred to and attributed to the fact that the trucks when equipped with plain solid tires were operated at a speed of 12 miles per hour whereas the pavement was superelevated for a speed of 9 miles per hour. The greater load which, under this condition, would be thrown upon the outer wheel, is doubtless the cause of the greater breakage which is shown by Table V to have occurred in the outer wheel strip under the plain solid-tired traffic. In the tests made with nonskid chains on the rear wheels the speed of the trucks was reduced to 9 miles per hour and it will be seen from the table that the breakage in the two wheel strips in this phase of the test was more nearly equal.

Table V—Transverse Breakage Occurring in the 2 in. Brick Section Under the Outer and Inner Wheels

Tire condition	Speed	Rated load	Number of trips	Number of brick broken transversely	
				Inner wheel	Outer wheel
		Tons			
Plain solid tires	12 miles per hour	3	10,000	0	0
		5	10,000	2	34
		7½	10,000	19	149
Nonskid chains on plain solid tires.	9 miles per hour	7½	10,000	10	63
		3	10,000	45	18
		5	10,000	20	22
		7½	2,300	12	4

Condition of the Test Pavement After Completion of Accelerated Tests. — Although the amount of transverse breakage has been taken as the criterion of the relative service of the several thicknesses of brick it must be understood that the transverse breakage alone did not materially affect the condition of the pavements. The broken portions remained in position, and under the plain-solid-tired traffic did not ravel or scale at the cracks except in the 2-in. sections. The number of brick broken during the entire test was less than the number that would ordinarily be broken during the rolling of a brick pavement.

The damage in all sections under plain-solid-tired traffic was practically limited to transverse breakage. Practically all the cobbling resulted from the operation of the traffic equipped with nonskid chains, and the greater part occurred during the early stages of this traffic. It seemed that after the corners of the bricks had become slightly rounded, further rounding took place very slowly. The spacing between the brick appeared to be a controlling factor in the amount of cobbling which took place; and brick laid with a wide spacing consistently showed greater cobbling. Edges of the cracks formed in broken bricks were rounded about the same amount as the original edges of the brick.

The condition of the brick in the several sections after the completion of the chain-equipped traffic is shown in Fig. 5. It will be noted that very little difference is apparent between the condition of the 2½, 3, 3½, and 4 in. brick sections, all being in almost perfect condition at the completion of the traffic test. The sections of 2-in. brick, on the other hand, show marked effects of the heavy traffic.

Test Traffic Compared With Traffic on Actual Highways.—It will be seen from the tonnage curve in Fig. 2 that a total of 62,200 trucks passed over the 30-in. strips of the test pavements, that about one-third of these were equipped with the heavy nonskid chains, and that the total tonnage moved during the period of the test amounted to approximately 630,000 tons.

A quantitative comparison of the traffic applied to the test sections with the actual traffic using a few heavy-traffic highways is made possible by the studies previously made by the Bureau of Public Roads of the transverse distribution of truck traffic on paved highways of various widths.[1] Using the data from these studies it is possible to estimate the maximum concentration of actual traffic on a strip of any given width in terms of percentage of the total traffic. Applying these percentages to the known traffic on certain heavily traveled highways it is possible to approximate the maximum amount of traffic passing over a strip of these highways 2½ ft.

[1]Transverse Distribution of Motor Vehicle Traffic on Paved Highways, by J. T. Pauls, Public Roads, Vol. 6, No. 1, March, 1925.

wide corresponding to the width of the traffic lanes on the test track.

For purposes of comparison in this manner certain highways in Cook County, Ill., have been selected. According to the survey of traffic on the highways of the county made by the Bureau of Public Roads and local authorities,[3] the truck traffic on these highways, shown in Table VI, is the heaviest to be found on any highways in the county. It is interesting to note, therefore, that the traffic of trucks of the several capacities applied to the test track is equivalent to the corresponding traffic over these highways in periods of from 2 to 146 years, as shown by Table VII. In terms of total tonnage the test traffic is equivalent to five years of traffic on the most heavily traveled of these important motor truck arteries.

TABLE VI—Daily Loaded Truck Traffic on Several Highways in Cook County, Illinois, in 1925

Name of highway	Width of pavement	Capacity of trucks						Total tonnage
		3 to 4 tons		5 to 5½ tons		6 to 7½ tons		
		No.	Tonnage	No.	Tonnage	No.	Tonnage	
	Feet							
Waukegan Road	18	19	143	18	190	8	120	450
Do	18	20	150	57	509	3	45	704
Lincoln Avenue	18	14	106	23	242	9	135	482
Dempster Street	18	3	23	6	63	1	15	101
Halsted Street	18	32	240	35	368	1	15	623
Ogden Avenue	24	76	570	29	305	3	45	920

In the above evaluation of the traffic applied to the test sections only a few of the most important truck-carrying highways were used for comparison. A more equitable comparison would probably be obtained were we to use the average of the truck traffic on the Cook County highway system. Compared in this way the traffic on the test sections is shown by Table VIII to be equivalent to the average traffic using all highways in the county in 18 years, and the test traffic of 6 to 7½ ton trucks to be equivalent to the corresponding actual in 70 years.

Table VII—Length of Time Required for Selected Pavements in Cook County, Illinois, to Carry on Two 30 in. Strips. Traffic in Number of Vehicles and Tonnage Equivalent to That Applied to the Test Pavement

Name of highway	Capacity of trucks						By total tonnage
	3 to 4 tons		5 to 5½ tons		6 to 7½ tons		
	By trips	By tonnage	By trips	By tonnage	By trips	By tonnage	
	Years	*Years*	*Years*	*Years*	*Years*	*Years*	*Years*
Waukegan Road	7	7	7	7	18	18	9
Waukegan Road	7	7	2	2	48	48	5
Lincoln Avenue	9	9	6	6	16	16	9
Dempster Street	44	44	22	22	146	146	45
Halsted Street	4	4	4	4	146	146	7
Ogden Avenue	2	2	5	5	57	57	5

[3]Highway Traffic and the Highway System of Cook County, Ill., by the Bureau of Public Roads and the Cook County Highway Department.

Table VIII—Average Trips and Tonnage of the Several Sizes of Trucks Passing Over the Highways of Cook County, Illinois, and the Time Value of the Test Traffic, Based on an 18 ft. Two-Way Pavement

Capacity of trucks	Average truck traffic on Cook County highways		Duration of actual traffic equivalent to that on test sections
	Trucks per day	Approximate tonnage	
			Years
3 to 4 tons	16	121	8
5 to 5½ tons	9	95	14
6 to 7½ tons	2	30	70
All capacities	27	246	18

Both the plain-tired and the nonskid-chain-equipped traffic applied to the test pavement was used in making the comparison shown in Tables VII and VIII. To obtain a comparison of that portion of the test traffic equipped with chains with similar traffic on actual highways, it is necessary to make an estimate of the portion of the year during which such traffic passes over the highways. It is believed that by estimating the yearly duration of this type of traffic at two months, ample time is allowed to cover the most severe conditions. On this or any other reasonable basis of comparison it will readily be seen that the test traffic with chains was far greater than any that could possibly come on any actual highway during the life of the pavement.

Table IX—Summary of Data of the Field Survey

Location	Thickness of brick	Type of brick	Area laid	Year laid	Character of streets paved	Remarks
	Inches		*Sq. yds.*			
Greenville, Tex.	2¼	Repressed.	12,000	1905-06	Main	First brick to be laid flat.
Do	2½	Wire-cut vertical fiber.	90,000	1914	Main and residential.	No 3-inch brick laid.
Sulphur Springs, Tex.	2½	do	60,000	1915	do	
Do	3	do	(1)	1915	do	No 3-inch brick laid since.
Tyler, Tex.	3	do	40,000	1920	do	Do.
Do	2½	do	140,000	1925	do	
Temple, Tex.	3	do	(1)	Before 1923	do	Do.
Do	2½	do	100,000	1915-1925	do	
Okmulgee, Okla	2½	do	220,000	1916-1923	do	
Do	3	do	30,000	Before 1921	do	Do.
Henryetta, Okla	3	do	25,000	1917	Main	Do
Do	2½	do	200,000	1917-1925	Main and residential.	
Wetumka, Okla.	3	do	12,000	1924-25	Main	
Do	2½	do	50,000	1924-25	Residential.	
Okeemah, Okla.	2½	do	35,000	1920	Main and residential.	No 3-inch brick laid.
Ponca, Okla.	2¼	do	500,000	1919-1925	do	Do.
Tonkawa, Okla	2½	do	110,000	1919-1923	do	Do.
Blackwell, Okla	2½	do	325,000	1913-14	do	Do.

[1] Not known.

The Results of the Physical Tests of the Brick.—The quality of the brick used in the several test sections is shown by the results of the physical tests recorded in Table III. These tests indicate that the brick used in the

test pavement were of about average quality, though some difference appears to exist in the quality of the different sizes.

Rated according to the moduli of rupture and crushing strength the test results indicate the order in quality of the different sizes to be as follows: 2½-in. (best), 3½ in., 4-in., 3-in., 2-in. (poorest).

Fig. 3—Condition of the 2-in. Brick Surface After the Completion of the Plain-Solid-Tired Traffic. Broken Brick Are Marked With White Painted Symbols the Shape of Which Indicates the Amount of Traffic Which Has Passed Over the Section Up to the Time the Break Occurred. For Explanation of Symbols See Table IV

The rattler losses, on their face, indicate a different order; but it has long been recognized that for brick of equal quality but different in size, the comparative rattler losses are not directly proportional to the differences in weight. Engineers have recognized the injustice of specifying the same percentage of wear for different thicknesses, and have adopted, very generally, the practice of allowing some tolerance for the thinner brick in comparing their rattler loss with that specified for the thicker brick.

It is apparent that the loss in the brick undergoing the rattler test is more nearly a function of the total length of edge than of the weight of the brick. In view of the increasing use of the thinner brick, it would seem, therefore, that some modification in the standard rattler test should be made so as to make it applicable to sizes of brick differing from that of the original standard block. Until such a modification is adopted, however, it will be necessary to correct the observed losses for the various sizes of brick so as to convert them to a comparable basis.

Applying the corrections recently suggested by the Bureau of Public Roads,[3] to the rattler losses of the various sizes as shown in Table III, the order of quality of the different sizes of brick used in these tests is brought into conformity with that indicated by the modulus of rupture and crushing strength tests.

The results of the compression test made on the brick taken from the test pavement after the completion of all traffic are given in Table IV. In making this test is was hoped to correlate the result of this test with service behavior. Comparing the crushing strength of the different brick with their condition after the test, it will be noted generally that good conditions both as to rounding and breakage were characteristic of the bricks giving the higher crushing results, while broken or badly rounded brick gave consistently lower values.

A striking point noticed in the data from the compression tests on the brick which had carried traffic was the consistently lower value obtained from this test as compared with the result of the same test on brick that had not been subjected to the heavy test traffic. It was first thought that this might be an indication of fatigue in those brick which had carried the heavy continuous traffic of the test. In order to obtain more data on this point additional tests were made. At first, a series of check compression tests was run. These test data, although consistent in themselves, did not agree with those obtained in the for-

[3]Effect of Size of Brick on Rattler Loss, by F. H. Jackson, Public Roads, Vol. 7, No. 5, July, 1926.

mer series of tests. It appeared that the difficulty might be, and probably was, due to the failure of the capping on the worn brick. Accordingly transverse bending tests were run on brick which had carried traffic and on those which had not and these results did not show the reduction in strength indicated by the compression tests.

The Field Survey.—By making a condition survey of thin-brick pavements in actual service, and by obtaining information from local engineers and highway officials regarding such factors as construction, age, climatic conditions, traffic, and maintenance, it has been possible to arrive at some conclusion as to the merits of the thinner paving brick in actual service.

Pavements in which brick less than 3 in. in depth have been in service for a considerable length of time are practically limited to portions of Texas, Louisiana, Oklahoma and Nebraska. The field survey was thus, of necessity, confined to this section. Every effort was made to obtain, through consultation with local engineers and highway officials, accurate information regarding all conditions which might influence the behavior of each pavement, and also their views as to the adequacy of the particular pavement to meet the traffic requirements.

Special attention was paid to the effect of the first attempt at using thinner brick on the subsequent policy with regard to brick thickness, using this criterion as a measure for the sufficiency of the design. The first thin brick pavement laid in a community in many cases can be classed as an experiment but similar construction later may be taken as an expression of the satisfaction of the community with the type of construction.

This survey involved a detailed inspection of the condition of several million square yards of pavements in which brick of 2½ and 2¼ in. thickness were used. Data on age, type of construction, type of traffic, maintenance, and other influencing factors were obtained for each pavement inspected.

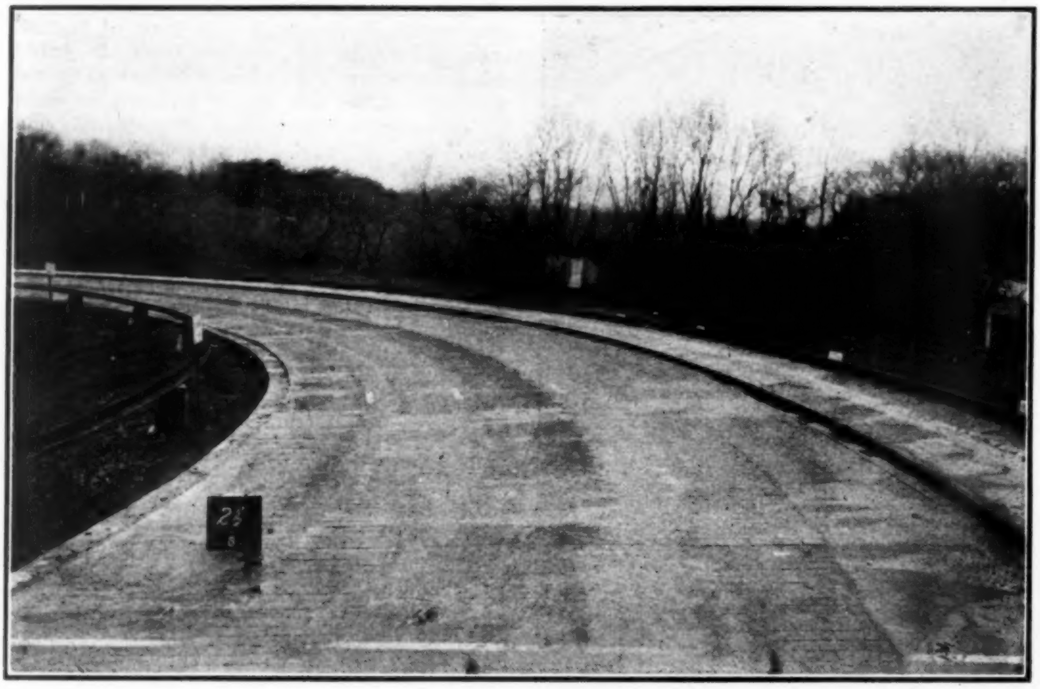


Fig. 4—Condition of 2½-in. Brick Strip Section Laid on Sand Bedding After Completion of the Plain-Solid Tire Traffic

The Indications of the Field Study Summarized.—A steady growth in the use of brick of less than 3-in. depth is shown by the field survey. Numerous communities were found which have adopted the thinner brick for use on some or all of their streets. Although the earlier work may be classed as experimental, as indicated by the small quantities put down and by the type of street selected for paving,

subsequent paving with the thin brick in larger quantities and on streets carrying heavier traffic may well be taken as an expression of the satisfaction of the community with pavements of this type.

Table IX shows a summary of data from some of the cities covered by the field survey in which brick of less than 3-in. thickness are used almost exclusively, which indicate these tendencies.

The pavements built with 2½-in. brick, in most cases, were in good condition. In a few localities failures had occurred in the base causing displacement in the brick. It was particularly noted that in such cases displacement in the brick had taken place without breakage. This was found to be true also for the brick over transverse and longitudinal cracks.

In general, the brick surfaces were found to have had very little maintenance, except at places where failure had occurred in the base. A portion of the brick pavement laid on Main St., Henryetta, Okla., during 1917, was refilled with asphalt during 1925, as the original filler had been largely carried away by traffic. Oklahoma enforces the 5-year maintenance clause on new paving work, yet the larger paving contractors declared, without exception, that no allowance is made or need be made in the estimated cost of a paving job to cover a difference between maintenance costs of 2½-in. and 3-in. brick.

It was found that excessive quantities of asphalt filler had been used in many sections of brick pavement. In one locality the excess covered the brick with a thickness of as much as one-half inch. Pavements where an excess of asphalt had been used were very rough, and will probably continue to be unsatisfactory for a long time. The importance of limiting the quantity of asphalt filler to that required to fill the space between the brick was strikingly illustrated by the unsatisfactory condition of such pavements.

Some changes in the construction features of brick pavements have occurred since the earlier pavements were laid. The bedding course of the early surfaces was found to range in thickness from 1½ to 2 in. laid on a rough base. Later construction shows, generally, that a ¾-in. bedding has been used on a smoothly finished base. In a few localities very fine sand had been used for bedding, but, because this type of sand shows a tendency to work up between the brick and because of loss through cracks in the base, coarser sand has been substituted as being more satisfactory.

The field survey showed that, in general, brick laid on a thin bedding course with a smoothly finished base maintained a smoother surface than those laid with a greater depth of sand on a roughly finished base.

The research of the last few years has proved that the destructive effect of motor-truck impact is greatly reduced by the construction of smooth pavement surfaces. The continued perfect alignment of the finished brick surface is dependent to a large degree, particularly on heavy traffic thoroughfares, on the smoothness with which the base course is finished and the resulting uniformity of thickness and compaction of the bedding course. Any slight increase in the construction cost for the purpose of obtaining this condition will be more than justified by the potential increase in the life of the pavement.

Cement-sand grout filler was found to have been used in the construction of some of the earlier brick pavements. Some of these were built with expansion joints in the brick surface, but in the majority of cases the joints have been omitted. The need of expansion joints with this type of filler was evidenced by the scaling in the surface of the brick on many of the pavements in which no expansion joints had been provided in the surface.

A wide range in the type and construction of base used was noted in the survey. Concrete ranging from 4 to 6 in. in thickness and largely of 1:3:5 proportion was found to have been used extensively in the area covered, while old and new macadam had been used satisfactorily in many instances. One city in the iron-ore belt was utilizing the iron-ore soil with entirely satisfactory results as base for brick pavements.

The successful use of these widely different types of base indicates that there is a wide range of possibilities in base construction. Any material which remains stable at all times would appear to make a satisfactory base for a brick pavement. It is evident that these requirements may be met in many cases by base construction of the less rigid type. As the function of the base is primarily to support the allowed wheel loads without appreciable vertical displacement, any type of construction that will meet this condition is satisfactory. An old macadam or other type of surface that has proved stable under traffic should prove entirely satisfactory as a base for brick.

In a majority of the locations covered in the field study no distinction was found to have been made in the base construction for brick of different thicknesses. One exception was noted where 3-in. brick had been laid on a compacted gravel base while concrete had been used for the 2¼-in. thickness. In this case

and in others where difference in the base construction had been made with the use of brick of different thicknesses nothing was found in the condition of the pavements that would indicate the need for any variation in obtained on the more important streets. Formerly there was a considerable percentage of heavy steel-tired vehicles which have practically been superseded by heavy motor trucks. Although traffic records were not available for

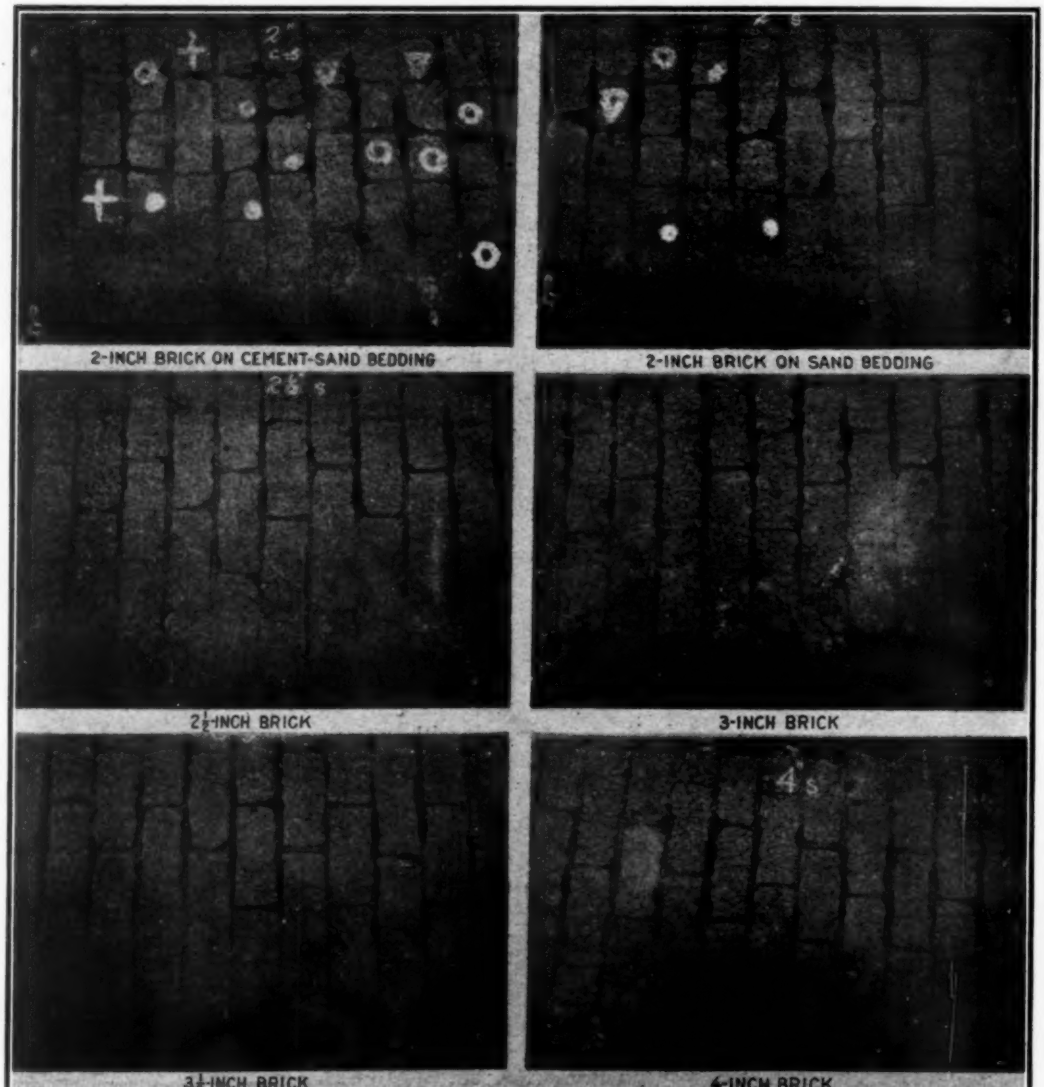


Fig. 5—Looking Down on the Several Sections After Completion of the Chain-Equipped Traffic. None But the 2-in. Brick Showed Sufficient Breakage to Justify a Conclusion as to the Effect of Type of Bedding. For Explanation of Symbols See Table IV

base construction for the different thicknesses of brick used.

Traffic.—A considerable number of the towns visited were located in the center of the oil fields and as a result severe traffic conditions study it is believed that the traffic on the important streets of the cities visited was more severe than that on the streets of many of the larger cities.

A great deal of importance is attached, and

properly so, to the views and experience of resident engineers and officials familiar with the use of brick under 3 in. in thickness. All of the officials interviewed from those sections of the country where brick of less than 3-in. thickness is being used expressed themselves as favorable to the use of the thinner brick, some with and others without limitations as to the type of street and traffic. Many maintained that 2½-in. brick would prove equally as satisfactory as the 3-in. thickness under all conditions, and others believed that the 2½-in. type should be limited to use on residential and outlying business streets.

The views of three prominent engineers who are intimately connected with the use of thin paving brick are expressed as follows:

Herman Beal, City Engineer, Omaha, Nebr.—I have completed an investigation of a pavement in the city built during 1915 with a 2½-in. surface. The following information being available:

Pavement on Parker St. between Twenty-ninth St. and Thirty-third St., 30 ft. wide, containing 5,360 sq. yd. Base 5 in. concrete, 1:3:6 mix. Bituminous filler.

This pavement is in excellent condition, the brick showing practically no wear and the surface, with the exception of one or two expansion bulges, being exceptionally good. The traffic on this street is what might be classed as medium, although occasionally heavy truck loads are hauled thereon.

Figure 23 is a detail view of the pavement described by Mr. Beal.

E. A. Kingsley, City Engineer, Dallas, Tex.—We have used 3-in. vertical fiber brick for a number of years, and are using in our heavy traffic industrial district this character of brick in paving some of our new work this year. Our first 3-in. vertical fiber brick was laid on Market St. during 1919. This pavement has extremely heavy downtown industrial traffic of both the rubber and steel tired type. We have no trouble from breaking or cracking under traffic of the 3-in. brick. We have found that this brick carries traffic equally as well as did the old 4-in. block laid on edge. We can discoverer no reason in studying the wear and service given by the 3-in. brick which would suggest to us that a 3½-in. or 4-in. brick might be better.

Dallas is perfectly satisfied with its heavy-traffic service on the 3-in. vertical fiber brick, and from experience that neighboring cities have had with the 2½-in. brick, we believe that this should be specified for the lighter traffic and residential districts.

D. Lewis, City Engineer, Fort Worth, Tex.—This city has been laying 2½ and 3-in. vertical fiber brick with asphalt filler on a cement-sand cushion laid on a concrete base. We have found this type of paving to give excellent results.

Manufacture of Thin Brick Practicable.—The manufacture of brick as thin as 2½ in. is accomplished without particular difficulty. Some loss from warping was said to have occurred when brick this thickness was first manufactured. Later changes in the manufacturing process, particularly in the burning, have made this loss negligible at the present time. The brick manufacturers in the sections of the country where the thinner brick are being used, were found to be favorable to the manufacture of the 2½-in. type. The manufacture of brick with 2-in. thickness was believed by some to be impractical because of the loss occurring from warping during burning.

Reduction in the cost of a brick pavement built of thin brick is the result decreased cost of such items as manufacture transportation, handling on the job, and saving in the filler material.

Based on the cost of a 3-in. pavement the saving in materials and costs for each ½-in. reduction in thickness would be approximately as follows:

	Cost Reduction	Material Reduction
Manufacture	10%	......
Freight	16%	......
Haulage	16%	......
Filler	16%	10%

Standard Municipal Contract Form

A standard contract form developed jointly by the American Society for Municipal Improvements and the Associated General Contractors of America will soon be ready for distribution. According to a member's news letter of the A. G. C. the sentiment of the A. S. M. I. was such that they could not move to adopt a wide-open arbitration clause as a part of the new form in giving the document their approval. The new form does provide, however, for a review of decisions made by minor officials, these reviews usually to be made by heads of departments. This, it is pointed out, will go far to minimize possibility of effective arbitrary decisions by minor officials that are manifestly unfair to the contractors involved.

The report of the joint committee that handled preparation of the new form quotes the arbitration clause approved by the Joint Conference on Standard Contracts and suggests that it be used in sections of the country where arbitrative activities are entered into.

The Fifth International Road Congress

Final Conclusions on Concrete Roads, Bituminous and Asphalitic Roads, Standardized Tests for Materials, Census of Traffic, Town Planning and Special Motor Roads

At the Fifth Annual International Road Congress, held Sept. 6-12, at Milan, Italy, under the auspices of the Permanent International Association of Road Congresses, 50 countries were represented by official delegations, the total number of representatives being well over 1,000. The official delegates from the United States were Thomas H. MacDonald, Chief U. S. Bureau of Public Roads; Paul D. Sargent, Chief Engineer State Highway Commission of Maine; John N. Mackall, Chairman State Roads Commission of Maryland; H. H. Rice, Vice President General Motors Corporation; Geo. Pyke Johnson, National Automobile Chamber of Commerce; H. C. MacLean, Commercial Attache, U. S. Department of Commerce at Rome, and H. H. Kelly, Assistant Trade Commissioner, U. S. Department of Commerce at Paris.

The subjects discussed by the Congress included (1) Concrete Roads, (2) Roads Using Bitumen and Asphalt, (3) Standardization of Tests for Acceptance of Materials for Roads, (4) Census of Traffic, (5) Development and Organization of Towns in the Interest of Traffic and (6) Roads Specially Reserved for Motor Cars. Some 50 or 60 reports on these subjects were presented, giving the practice and experience in many of the leading countries. Some 20 reports were submitted on concrete roads alone, these dealing with the methods and experiences in the United States, Great Britain, France, Denmark, Italy, Belgium, Sweden and the Low Countries. Reports on bituminous and asphalt roads were presented by representatives from the United States, France, Great Britain, Italy, Belgium, Sweden, Switzerland and Holland.

The adoption of the final conclusions on the various subjects enumerated above met with very little opposition except in the case of special highways for motor vehicles. On this subject the delegates from the United States and Great Britain refrained from voting. The final conclusions adopted by the Congress were as follows:

CONCRETE ROADS

(1) The development of cement concrete roads which has taken place with good results, even on routes traversed by heavy vehicles with tires, serves to demonstrate the suitability for traffic of this kind and in great volume, when such roads have been constructed in every respect by the improved methods which have already been adopted by road engineers. For roads over which pass a considerable number of vehicles with metal tires, no satisfactory system has yet been evolved.

(2) The experimental tests with special concretes must be continued, as those so far carried out even under the ordinary conditions of traffic have given no reliable results.

(3) The general proportions laid down at Seville for the composition of concrete having been confirmed, the proportion of cement must in every individual case be specially determined in accordance with the thickness to be adopted for the slab and the quality of the materials available.

(4) The experimental tests in connection with the technical and economic suitability of metal reinforcement in concrete roads, as compared with other forms of construction intended to preserve the concrete work where the foundations are not very firm and are subject to special stresses, must be continued.

(5) Engineers are still very divided in opinion upon the advisability of transverse and longitudinal joints in concrete carriageways. When recourse is had to joints, the intervals between them are extremely variable. Observations should therefore be continued.

(6) As to the jointing material to be adopted when joints are provided, experiments should be pursued in order to ascertain the best type, with the object of simplifying as much as possible the mode of preparation and the method of application.

(7) The practice of constructing roads with alternating slabs, for the purpose of reducing the dimensions of expansion joints and of diminishing cracks, deserves attention and should be further investigated.

(8) The coating of concrete roads with hydro-carbano or bituminous mixtures may, in many cases, be productive of notable advantages, and should be further investigated and carefully examined.

(9) The experimental tests in connection with the silicatization of the surfaces of concrete roads with a view to their being made harder and to secure better preservation must be continued.

(10) The use of mechanical processes for the construction of concrete roads is advisable from the technical point of view, whenever economic difficulties or special working conditions are not encountered.

(11) For repairing damaged parts of such roads, the use of mechanical appliances is to be favored, quickly hardening cements or aphalt concretes being employed for repairs according to local possibilities and seasonal conditions.

BITUMINOUS AND ASPHALTIC ROADS

Natural Rock Asphalt.—(a) The asphaltic rock must be homogeneous and free from any foreign substance, entirely impregnated with bitumen, and must not contain clay in any appreciable quantity. It is recommended that the maximum limit be 2 per cent estimated in oxide of alumina.

(b) The percentage of bitumen, which may vary between wide limits from 6 per cent to 13 per cent obtained; if necessary, by blending appropriate proportions of natural asphalt rock or by the addition of hydro-carbons, must be controlled according to the climate and traffic, remaining within the lower limit in very hot climates and with very heavy traffic, and within the higher limit in the reverse case.

Non-asphaltic Mineral Materials.—(a) Mineral materials, not naturally asphaltic, and used in bituminous roads, are classified as follows:

Coarse aggregate—retained by a screen ¼, or 6 mm., square mesh.

Fine aggregate—passing through the above screen and retained by a Standard No. 200 screen, or with 6.200 meshes per square centimeter. Filler—passing through the above No. 200 screen.

(b) In the layer exposed to traffic of any type of bituminous road, use should be made as coarse aggregate of a stone or gravel, or a mixture of these materials, obtained from hard and tough rock, preferably of volcanic origin or limestone. Some clinkers are also used with good results.

(c) In the lower layer of double-coat roads, use may also be made of second class or scrap materials, but increasing the quantity of bitumen in the mixture accordingly. In each particular case, the choice of the coarse aggregate must be made with a view to economy, by endeavoring to utilize the less costly among the sufficiently good materials.

(d) The maximum size of the coarse aggregate depends on the type of road, the method of execution, the nature of the traffic, the quality of the foundation. For roads of the macadam type with penetration and for the lower layer of double-coat roads, the limit to be adopted, according to the present practice, should be the dimension of 2½ in., or 65 mm., except in special cases. For the wearing surface of double-coat roads and for single-layer roads made on the mixture principles, the maximum dimension should be 1½ in., or 40 mm. But in some very common types, 25 mm. are not exceeded. It is recommended, in any case, that the size of the material should not exceed half the thickness of the road layer concerned. It is further recommended that as traffic increases the maximum dimensions of the fragments of stone be proportionately reduced.

(e) As a rule, the coarse aggregate is required to be supplied in several sizes, two at least, and that the various sizes be proportioned so as to obtain a whole of a maximum density, that is to say, so as to reduce to a minimum voids to be filled with the bituminous paste. In some roads mostly formed of a compact asphaltic paste, the coarse aggregate may also represent a small portion of the mass and have the sole purpose of rendering the mass itself less plastic and running; in such cases, the sizes of the coarse aggregates are usually very limited—from ¼ to ¾ in.—and it is then preferred that the size of the material be uniform.

(f) Fine aggregate may consist of sand of any description, provided it is sound and free from any impurities; also of fine chippings from the crushing of rock and certain clinkers. For fine aggregate, a correct graduation is specified between certain limits regarding the percentage which must remain between two successive screens of the standard series, the object being to give a maximum compactness to the bituminous paste.

Should any given material lack any of the elements required to obtain the correct graduation desired, this must be adjusted by mixing another suitable material with it.

(g) For filler, it is advisable to use ordinary Portland cement, or finely powdered hydraulic lime, or again, a fine powder recovered from the grinding of a suitable stone. It is advisable that the material used as filler should not leave more than 20 per cent of residue on a Standard No. 200 screen. It is recommended not to rely for a filler on the portion of a fine aggregate which passes through the Standard No. 200, as this "fine material" should rather be considered as impurities in the "fine aggregate."

Bituminous Binding Material.—(a) The tests at present in use for bituminous materials are sufficient on the whole, to ascertain whether a given bitumen is suitable for a given road under given conditions. The Congress, however, expresses the desire that a practical method may also be found of measuring the dimension of a bituminous binding material to an aggregate, and that a complete study should be made of the action of the very fine mineral matter incorporated in bituminous binders, on the so-called asphaltic characteristics of the binding material itself.

(b) The penetration figure, usually determined at 77° Fahr. or 25° C., though it may

be taken as sufficient to ascertain the constancy to type of a bituminous binding material, provided that the origin and method of preparation are also constant, is not sufficient to give the suitability of such a material to the requirements of a given use. It is recommended to add to specifications for bituminous binding materials, the softening or melting point, obtained for preference by the ball and ring method.

(c) The ductility test, carried out at the one temperature of 25° C., in certain cases is of little significance. It is recommended to add to the specifications a low temperature test —say, at zero—and also a test at a higher temperature, when dealing with bitumen which, at a temperature of 25° C. give an elongation not exceeding 50 centimeters.

(d) For asphaltic binding materials it is recommended that the asphaltenes be determined by solution in naphtha, naphthalene or petroleum ether. When standardizing the methods of testing bituminous materials, it will also be necessary to define the characteristics of this solvent, to specify its nature, its density and the limits of distillation.

(e) The penetration figures, suitable for the various bituminous roads, vary considerably according to the method of execution, the climate, and also the quality and intensity of traffic to which they are subjected. The degree of penetration must decrease in proportion with greater compactness in the mixture, greater fineness of aggregate, greater heat and dryness of climate, and greater intensity of traffic.

It is impossible to state—*a priori*—the figures corresponding to each combination of these variable factors. The particular cases, however, mentioned in the reports to the Congress, may well serve as a guide for a rough approximation, the assistance of local experience being necessary in any case.

In several countries good results have been obtained by preceding the surface bitumen treatment by a preliminary surface dressing with tar. This method is specially recommended for macadam surfaces composed of friable and dusty materials. Further in the experience of several countries, the mixing of bitumen with a percentage of suitably prepared tar facilities bituminous coating.

It appears that the addition of tar to an asphaltic binding material, when making asphalt concrete, makes it possible to apply the mixture at a lower temperature. There is therefore good reason for a close study of these mixtures of bituminous binders with tar and its derivates, either for improving the conditions under which use is made of the materials themselves, or for the sake of economy, wherever the cost of tar and derivatives is considerably lower than that of bitumen.

Standard Tests for Materials.—The Congress is of the opinion that a committee to meet in Paris (headquarters of the Permanent International Association of Road Congress) should be appointed by the Congress for the purpose of:

(a) Settling a nomenclature for the principal materials and methods employed in connection with road construction.

(b) Standardizing the methods employed in taking samples and in testing the materials in question.

The Congress asks the Presidential Commission of the Congress to appoint this committee in consultation with the Central Bureau of the Permanent International Association of Road Congresses with the reservation:

(a) That the committee should represent the languages admitted at the Congress as well as Spanish and one of the Scandinavian languages.

(b) That the committee should nominate with representatives of other languages according to the nature of the subject.

(c) That in every case there should preferably be appointed to the Commission representatives of the various national associations already appointed for this purpose in the different countries concerned.

TRAFFIC CENSUS

(1) The results of the census will be set out with reference to each section covered by an observation post.

(2) For each section an indication will be given of the daily average deduced from all the days of observations, which must be specifically indicated, as well as the month or months in which the observations have been taken, and the daily duration. These averages will be reduced to the twenty-four hours by suitable additions for night traffic.

(3) For each section an indication will also be given of the yearly averages for the traffic units in each class separately, taking into account the period of census and of possible varitions for other reasons established through special experience and observation. This will make it possible to know the number of vehicles of each group passing in one year on the section under consideration.

(4) Whatever may be the classification of individual vehicles in the various countries and on the various roads for special purposes and in connection with special local conditions, the users of the road should be grouped into the following classes: (a) Animal traction vehicles; (b) mechanically propelled commercial vehicles and motor omnibuses with pneumatic tires; (c) mechanically-propelled passenger-carrying vehicles with pneumatic tires (*i. e.*, motor cars not including motorcycles); (d) mechanically-propelled vehicles with solid tires; (e) motorcycles; (f) bicycles; (g) pedestrians; (h) animals unharnessed or ridden; (i) hand carts, etc.

The last four groups are accessory, and will only be counted if it is considered necessary.

(5) The results of the statistics will be indicated, and also the following data which may vary from country to country, and from road to road: (a) Average gross weight attributed to vehicles of each group, bearing in mind the variable proportion between heavy and light vehicles, the probable number of vehicles empty or partially loaded and, for animal-drawn vehicles the proportion between those with one or several draft animals. (b) Average width of the section of road under consideration, taking into account the modifications necessary owing to the presence of tramway lines. (c) Length of the same section. (d) Nature of the road surface and the state of repair. (e) The weather at the time of the census. (f) As an addition and accessory, the average useful weight carried by the vehicles unit of each group, as regards good vehicles only.

(6) It would be desirable that each nation, in connection with its census, in order to make the results comparable, should give for each section on which the census is taken—(a) The average daily numbers registered under each group of users of the road. (b) The average gross daily tonnage.

(7) An international committee should be appointed by the Congress to consider the standardization of census returns, in the light of the present conclusions.

THE DEVELOPMENT AND PLANNING OF TOWNS IN THE INTERESTS OF TRAFFIC

(1) An exact and correlated study of the building regulations for cities and of schemes for their planning and extension is one of the fundamental conditions for satisfactory street traffic, and what is even more important, for the general welfare of the community. This study should be co-ordinated also with the street regulations of the police, both those in force and those it is proposed to adopt. Above all, therefore:

(a) Every modification in the building regulations should be associated with a modification in the fundamental plans, which takes into account the effect on street traffic of the altered building conditions.

(b) No scheme for the modification of the street system can ignore the police regulations for the control of the traffic, though the aim should be to reduce these regulations to a minimum.

(c) An accurate and statistical statement as to the traffic conditions should serve as a guide in any scheme of town planning; a consideration of the building regulations proposed for various districts in an extension scheme, and an examination of their relation to each other is essential in the planning of the street network scheme.

The extension scheme must cover a sufficient area to include the points of origin of the streams of traffic; it must not be elaborated in every detail, but must be regarded as a skeleton plan of the principal lines of traffic. It is also essential to take into account considerations connected with traffic control, the configuration of the town in question, and the uses to which the buildings and streets are to be put.

(d) The plan must control the use of the land in the various quarters, fixing in relation to this use the building lines, and the widths of the streets, the height of the buildings and their distribution.

(2) It may be difficult for economic, historic or artistic reasons, to introduce into the central nucleus of a city such an orderly layout as is required by modern needs. Recourse must therefore be had to partial expedients to lessen the inconveniences inherent in a network of streets conditioned by the density of the buildings and of present-day traffic. Such expedients may take the form of:

(a) Local improvement in the street network.

(b) Improved traffic control in the streets as they are.

(c) The diversion of traffic from the central nucleus.

(d) The decentralization of offices and industries which may, with advantage, be transferred to the outskirts of the city.

(3) Any amendment made in the street system within the central part of the town should not be a merely local scheme, but should form part of a general scheme to systematize the central nucleus itself, and also to take account of the requirements of traffic as a whole and of communication between the several districts.

(4) The difficulties in the way of any widening of the street sites in the centers of the cities to make them adequate to the volume of traffic, render it necessary to raise the efficiency of the existing streets. The following methods, most of which had already been indicated at the Congress of Seville, have proved effective in practice.

(a) The exclusion from streets intended for dense traffic of whatever is not strictly necessary, either in the form of stationary or moving objects, and above all to avoid:

(I) The locating of shrines, sentry-boxes, kiosks, market-booths, coffee-stalls, advertisement-hoardings, etc.

(II) The parking of vehicles.

(III) The transit of slow and cumbrous vehicles.

(b) As a counterpart of these prohibitions, it is necessary that any plan for the layout of the central part should provide facilities

(I) For the widening of streets where urgently necessary.

(II) For the making of spaces or buildings for the parking of vehicles and above all for the reception of automobiles.

(III) For constructing or organizing lateral arteries alternative to the main traffic thoroughfares, through which the slow and heavy vehicle traffic may pass.

(c) The removal of anything tending to create an interruption in the steady passage of the vehicles and more particularly: by means of overhead ways or combined signals; by the adoption of one-way traffic where necessary; the avoidance of too long and too frequent stoppages at the crossings in the leading thoroughfares; by scrupulous supervision on the part of the street police; by preventing the normal flow from break interrupted by the turning of individual vehicles so as to break into the stream of traffic.

(5) The construction of elevated and underground streets has not yet been carried far enough to warrant the inference that they will provide effectual relief for the traffic.

It may be remarked, however:

(a) That the utilization of the subsoil for the purpose of relieving the street-level traffic should form part of a general plan embracing the co-ordination of the urban underground railways, with the provision of auto garages, subways, and possibly also underground tramway stations.

(b) That pedestrians avoid using the subways mainly because these are approached by stairs which seem to constitute a barrier to traffic. It is recommended that where possible gently-sloping ramps be provided as approaches to the subways, and that the subways themselves may provide some attraction from shops, etc., located in their sides.

(c) The same principles should apply to the construction of overhead ways.

(6) The suppression of tram lines in the heart of the city should be carried out step by step as facilities arise from the development of other and less cumbrous means of public transport and, above all, from the construction of underground lines in localities where they do not now exist. In cases where such lines are already in existence, it should not be forgotten that their capacity is not unlimited and that the suppression of the tram lines can only take place if the underground lines can carry a heavier volume of traffic. In order to prevent increasing congestion it is desirable that all forms of public passenger transport should be co-ordinated and should be under the control of the same administration.

(7) The diversion of traffic from the heart of a town should be effected:

(a) On the basis of a comparative study of the plans for extending the town, and for systematizing the layout of its center. Every extension of the town should be designed not merely by itself, but also with regard to its effects on the lines of communication with the center, with the other districts of the city, and with its suburbs.

(b) By the distribution of the traffic, which should be done by the making of wide arteries to divert it by the quickest route from the thoroughfares which convey the traffic into the city to its various quarters of destination. The construction of concentric ring roads to knit up the radial thoroughfares has proved to be less advantageous the larger the diameter of the circle becomes.

(8) The displacement of large administrative services to the outskirts is advisable in the interests of the street traffic when such service can be divided up into departments each enjoying a large measure of autonomy. Otherwise the displacement may result in an increase of traffic.

(9) It is preferable that the public transport services should carry the passenger traffic to points near to the center, while avoiding the spots already overburdened with traffic.

(10) The distribution of areas according to the type and use of building (zoning) may promote a good circulation of the traffic if the distribution of the several quarters has been systematically planned. In this connection it is necessary to remember that widely-spaced buildings of large size may be responsible for a large increase in the number of vehicles, and thus congest the traffic in business quarters.

(11) Keeping always in view the reservation of the streets for moving traffic, it is necessary, in the distribution of the quarters, to keep in mind the necessity for maintaining areas reserved for parking vehicles, and for parks and gardens for children's amusement.

(12) The planning of the street network in new districts should take account of the traffic requirements and give primary consideration to the following factors:

(a) The construction of a ground network fixing the traffic axes.

(b) The determination of the streets that are to distribute the traffic.

(c) The exact designing of the interconnections of the streets with each other and more particularly of their inlets and outlets.

(13) The main thoroughfares should allow of the laying out of separate tracks, specially adapted to different forms of traffic. They should be capable of being widened so as to meet future requirements. Steps should be taken to provide facilities for pedestrians to cross these arteries of traffic.

(14) The principal arteries of urban traffic must be co-ordinated with the arteries of traffic in the surrounding areas. From this point of view it is desirable that the schemes should

take into consideration whole regions and co-ordinate their lines of traffic.

(15) It is desirable that street control and street signalling should form a co-ordinated whole. More particularly, the street signals should be conveyed not only in printed character; the form and color of the signal should make its meaning understood at a glance without the necessity of reading the inscription.

(16) Systematic control of traffic has been steadily extended. It is desirable that this control should assume everywhere common characteristics. This would call for the fullest collaboration between the associations of road users and the public authorities.

The Congress expresses the hope that steps will be taken as soon as possible to call a diplomatic international conference, with a view to securing uniformity of traffic signals in urban areas by means of signs which can be easily understood without the necessity of reading an inscription.

SPECIAL MOTOR ROADS

Conditions Justifying the Creation of Motor Roads.—(a) The creation of roads reserved for the use of motor traffic may be considered as justified when the mixed traffic on the ordinary highways in the neighborhood of, or between, densely populated centers, or passing through places which have a busy industrial, commercial or pleasure traffic leads to a saturation and a deadlock dangerous to the circulation and contrary to transport economy. Also when the absolute preponderance of motor traffic of every kind (passenger, goods, fast and slow units) render it necessary to ensure for it the highest possible return in the form of speed, non-stop running and safety.

(b) When estimating the foregoing conditions, extreme prudence must be observed, and one must not let oneself be carried away by a spirit of easy optimism. On the one hand must be weighed the benefits obtained from economy in transport (time, wear and tear, staff), and the savings effected by not carrying out the difficult and too costly improvements to existing roads which with careful maintenance or with only slight improvements might still be made to serve, as against the outlay required for the construction, upkeep and running a motor road. Other elements, too, and not to be valued in figures, must be borne in mind, such as safety to life and limb, general advantages to the towns and districts directly interested under existing conditions, and in the light of probable developments.

(c) As, generally speaking, the motor road cannot replace existing highways, neither can it pretend to exclude motor vehicles from them, even over the same distances.

Execution and Control of Works.—(a) The construction and running of a motor road, even when not aided by public bodies, must always be the subject of concessions on the part of public authorities.

(b) Even when the line of motor roads does not materially pass beyond the boundaries of a province, township or borough, etc., the concessionary powers must always be reserved to the State, which is the supreme guardian of public interests and supreme regulator of the juridical and economic relations between public and private persons.

(c) The control of the construction and use of a motor road as a consequence of the concession will always be in the hands of the State, and in particular, will be subject to the direct control of one of the executive departments.

(d) The concession should be limited in duration, and it would be desirable to provide for a power of purchase by the State at any time during the duration of the concession.

Finance: Contributions by Public Bodies: Tolls.—(a) On these points it is not possible to draw up general and absolute rules. Where the use of motors is widespread, it may not matter much whether the motor road is financed out of the nation's general balance or from a general motor tax. Where there are but few cars on the roads it would be unjust that all the citizens or even the car owners alone should be called upon to pay for the motor road. In this case instead, it is quite fair and natural that a special tax should be levied upon those who willingly make use of a speedier and more convenient means of transport over certain distances, while they are still free as any other motorist to choose between the motor road and the ordinary road.

(b) This system of special taxation by which the motor road pays for itself means to say that there would be no motor road undertakings where, after due inquiry as to the possibilities of the traffic, a sufficient income deriving from taxes and other charges could not be relied upon. Nevertheless, the regime of a special tax does not exclude subventions by public bodies in consideration of general public interest, which cannot be precisely valued. The subventions may be of different form and varying degree. For instance, they may assume the form of donations, repayable loans, guaranteed interest on capital or only part capital.

(c) The tariffs for the use of the motor road must, in the interest of the puolic, be approved by the public authority if only in order to guarantee equality of treatment to all. They must be such as not to exceed the economnic advantages of motor road transport over ordinary road transport, they should not be unduly complicated, and should be so sectionised that they do not hinder the utilisa-

tion of the motor road by intermediary centres and the districts passed through.

Rules for Operation.—(a) Since it treats of a public service even if of private initiative, the rules and by-laws must be approved by the State.

(b) Motor roads must be absolutely independent and separate from all other roads and from all property without their bounds. They must, therefore be rigorously fenced off throughout their entire length. They must have gates at their extremities and on all roads giving access to them and there must also be gatekeepers. This rule is quite independent of whether tolls are demandable or not.

(c) The ordinary regulations for the control of traffic should be enforced, and also rules similar to those in force on railways to prevent entry and trespass.

It may be anticipated that on motor roads higher limits of speed will be permitted than those in force on the ordinary roads. But drivers will have greater responsibilities and there will be severe penalties for those who allow cars to get out of control, who fail to heed the traffic by-laws, signals and orders.

(d) So long as heavy motor lorry traffic does not become exceptionally intense and provided that the motor road is sufficiently wide to allow of vehicles to pass one another while still keeping to their right side it is neither opportune nor necessary to divide the traffic into light and heavy and run them on different tracks.

(e) Vehicles may turn back without being obliged to go out and re-enter, provided that they do so where there are keepers who can take the necessary precautions and set the signals.

(f) Stops, save in response to signals or orders, must only be made near the banks running alongside or at the special stopping places.

(a) Level crossings, either road or rail, must be excluded absolutely. The continuity of the motor roads must be ensured by means of tunnel bridge. Nevertheless, the public secondary and private roads can be indirectly linked up by making them open out, singly or in groups, on to the chief ways so as to take advantage of the bridges and tunnels attached to them. The competent authorities when approving the scheme will be careful to see that the local interests and road systems of the districts to be traversed are affected as little as possible.

(b) The motor road junction roads connecting up with neighboring centers and existing highways must be chosen and laid with due regard for the importance of the district to be traversed; must be sufficiently wide and to allow for perfect visibility where they open on to the motor road; must be furnished with signals at suitable distances on both sides and be supplied with a toll bar and a toll keeper.

(c) Theoretically, it is desirable for vehicles entering and leaving by means of the junction roads not to cross the track reserved for the opposite direction to their own. But these crossings may be effected without inconvenience or danger by the observance of the rigorous discipline for the control of traffic which is essential to the motor road. Consequently, except in cases of extreme difficulty and traffic congestion, one can do without costly and complicated methods, such as junction branches and circuits provided with bridges and tunnels, which otherwise would be necessary in order to eliminate them entirely.

Good Roads Week at 1927 Road Show

Plans are under way for the celebration of Good Roads Week under the auspices of the American Road Builders' Association from Jan. 10th to 16th. The National Education Association and the National government have been asked to assist in featuring the highways of the country in special exercises during that period.

President H. G. Shirley of the Road Builders has stressed the necessity of acquainting the school children of the nation with the location and economics of the 3,000,000 miles of roads estimated throughout the country, and says,

"An intimate knowledge of the manner in which highways are originally financed and how the investment is returned through a saving in the cost of motor transportation, is very important to the youth of this country. If a child has a fundamental knowledge of the value of Good Roads, the man he will become will not be retarded by a doubt as to their advisability. The result will be that American highways will attain an almost perfect state of development under the regime of the coming generation."

Mr. Shirley also urged the school officials of the nation to establish definite periods during the first half of the coming school year for the study of traffic regulations and safety measures.

"The study of traffic rules and safety measures will without doubt decrease the enormous number of fatalities among the young people of this country," he said. Mr. Shirley also announced the tentative plans for a national essay contest to be carried on among the students of America, and prizes for which will be awarded by the American Road Builders' Association at their annual convention in Chicago during Good Roads Week, January 10 to 17, 1927.

The Design of Macadam Roads

Improvements Suggested in Journal of National Crushed Stone Association

By A. T. GOLDBECK

Director Bureau of Engineering, National Crushed Stone Association

Unquestionably the topic of macadam road design is a timely one and a full discussion should serve to crystalize our thoughts as to the ways in which we might improve this type. In considering the macadam type, I think it essential that we rely not on cut and try methods of improvement, but rather should we take steps which have been developed as a result of engineering analysis. I trust that none of us will be unwilling to admit of the possibility of making the macadam type an even better road than it is at present, just as it is possible to improve every other kind of road. Under the term "macadam type" I include broken stone base with a water-bound macadam top, with or without a bituminous surface treatment, a bituminous macadam or a bituminous concrete top. The present remarks, in short, deal with the "flexible" as contrasted with the "rigid" types of surfacing.

The Macadam Road Design Problem.—The macadam road should be considered as a structure which must resist external forces. To design any structure, the engineer must make an analysis of the forces and destroying agencies which act; then his task is to so proportion his structure that it will successfully and economically resist those forces and agencies. The rational design of a macadam road has not as yet been accomplished, probably because of the great complexity of the problem. But this should not deter us from attempting an analysis and perhaps through discussion, trial and further analysis there will be brought about better and cheaper flexible road types.

Let us first consider the forces to which a macadam road is actually subjected, and see how these forces are resisted. We shall omit any thought of surface disintegration for the present but shall confine ourselves entirely to the effects of heavy wheel loads.

The Forces Due to a Wheel Load.—A macadam road in its most usual form, consists of a layer of crushed rock keyed with smaller stone and compacted by rolling. Ordinarily large stone, say from 2½ to 3½ in. in size is used in the base course, and smaller stone from 1½ to 2½ in. in size in the top. In addition to the compaction from rolling during construction, traffic further compacts such a layer, provided it is protected from surface raveling through the use of a binder. If it were possible to remove a slab from a macadam road and mount this slab as a simple beam on two end supports, it would be found that this beam would be capable of supporting very little external load. For practical purposes, then, the resistance to bending or "beam action" of a macadam surfacing is very slight.

Without even considering the possibility of a mathematical analysis let us review the forces which act in supporting a wheel load applied somewhere near the center of a macadam road. Several years ago by means of special soil pressure measuring apparatus, the distribution of pressures under a broken stone slab was measured by the U. S. Bureau of Public Roads. A curve of the general

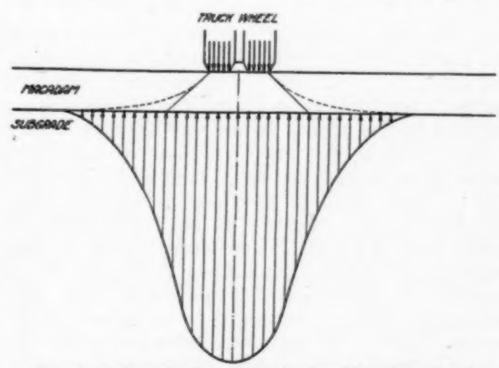


Fig. 1—Subgrade Pressures Under Macadam Road

nature of that shown in Fig. 1 was obtained. This curve shows how a macadam road distributes wheel load pressures to the subgrade. Notice that the vertical pressure on the subgrade is greatest under the wheel and tapers down to zero at a small distance away from the wheel. Notice that our ordinary assumption, that the entire load is supported on the subgrade included within lines drawn at 45 degrees from the load, is not quite correct, although most of the load is supported by that portion of the subgrade confined within these lines. The curves drawn would vary in both width and pressure intensity depending on the characteristics of the subgrade, and, also, without question, the degree of compaction, or keying of the macadam will likewise influence this distribution.

Influence of Compaction.—If the stone were loosely laid on the subgrade, the load would

be spread, very largely by virtue of the overlapping of the individual stones upon those below. This is crudely illustrated in Fig. 2, in which the short vertical lines at the contact points indicate vertical forces, only, acting on the stones. Here the load is spread over a comparatively small area of the subgrade. On the other hand suppose the layer of stone is well compacted and keyed. In this case as shown in Fig. 3, a considerable amount of horizontal pressure is developed on each stone

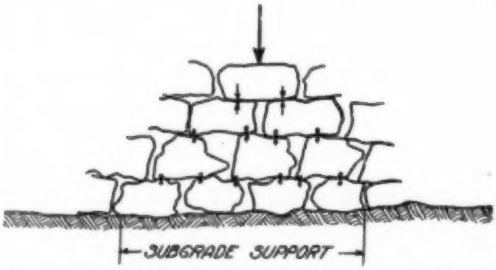


Fig. 2—Sketch Showing How Vertical Load Is Carried to Subgrade Through Uncompacted Stone

and, hence, considerable vertical friction exists at each point of vertical contact of one stone against its neighbor. Consequently when a load is applied on a given stone it is transmitted to the stones below not only by virtue of the fact that it rests on them directly, but also because the stones immediately adjacent to it carry part of the load which is transmitted to them because of the high frictional resistance between the adjacent stones. Also the cause of the high lateral restraint of the stones it seems entirely probable that considerable arch action might be developed under wheel loads. It follows, therefore, that the more compact the layer of stone, the wider will be the distribution of the wheel load over the subgrade. The following statement can be set down as one of great importance in the proper construction of a macadam base or roadway:

1. Through rolling and keying should be used so that the individual stones shall be compacted tightly into position. High lateral restraint is thereby developed and wheel loads are better distributed over the subgrade.

Effect of a Load at the Edge of the Macadam Surfacing.—We have considered thus far a load placed at an intermediate position in the pavement. This is a very favorable position for distributing load to the subgrade, for here the surfacing material is wedged tightly into position by the surrounding compacted mass of stone. At the sides of the road, however, the stone is held laterally only by the earth shoulders and in the spring of the year this restraint is almost zero. Undoubtedly then, one of the weak points of the macadam road is the lack of sufficient lateral restraint for the stone at the sides and here an improvement in design might well be attempted.

Effect of Road Thickness.—Obviously if the wheel load be placed directly on the subgrade, the full load is supported over the area of contact of the wheel with the subgrade and the subgrade pressure under the wheel is then of the greatest intensity possible. If a layer of stone be used the pressures are spread over a wider area on the subgrade and consequently the intensity of pressure is decreased.

2. The thicker the layer, the lower is the intensity of wheel load pressure on the subgrade.

This, too, has been definitely proven by means of special tests made to determine the distribution of loads through earth fills. The laws governing the influence of the thickness of a stone layer on pressure distribution to subgrades of different supporting characteristics are unknown and this is a fundamental research which should be undertaken.

Influence of the Subgrade.—Obviously the softness of the subgrade will influence the wheel load distribution and wider pressure distribution can be expected over a soft subgrade than over a hard non-yielding material. The subgrade plays a vital part in affecting

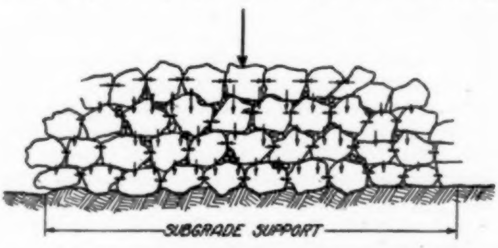


Fig. 3—Showing How Compaction Develops Horizontal Force and Hence Friction Which Aids in Transmitting Vertical Pressures Over Larger Areas Than When Stone Is Uncompacted

the stability of a broken stone surfacing. If the pressure transmitted be too great, the subgrade will yield under the load and immediately high shearing stress will result in the road surfacing which will destroy its mechanical bond and render it much more susceptible to destruction from subsequent loads. Moreover, considerable yielding of the subgrade under a wheel load will result in plastic flow of the subgrade material and this causes a pushing up of the surfacing on each side of the load. If the load is placed near the side of the road, plastic flow will take

place with greater ease toward the side of the road and under such adverse subgrade conditions, broken stone surfaces develop depressions near the side and the extreme edges might be raised and moved out toward the shoulders.

3. A broken stone road requires excellent subgrade support.

The important point is that the unit pressure transmitted by the surfacing to the subgrade be kept well within a value which will cause excessive subgrade movement. As already pointed out this means:

A. The use of sufficient thickness of stone.
B. Its proper compaction and to these should be added.
C. The adoption of means to increase the subgrade resistance to the highest possible value.

Subgrade Characteristics. — Unquestionably the subgrade plays a major role in influencing the stability of a broken stone road subjected to heavy traffic, and it becomes important that the subgrade characteristics be taken into consideration. Soils vary widely in their physical properties, due to the extremely wide differences in their physical and chemical make-up and to the manner in which they have been formed. Soils have resulted from the decomposition of a wide variety of rocks, and these decomposed products have been deposited under widely different circumstances. Naturally then, soils vary from those which are extremely finely divided or colloidal in their nature to the coarse grained sandy or gravelly materials. Much has been written on the methods used for analyzing and classifying soils from the road building standpoint. In general, it might be said that the extreme characteristics of subgrade soils are as follows:

Bad Soils

a. Extremely fine state of subdivision (as in clays).
b. High moisture capacity.
c. Extreme plasticity.
d. Difficulty of drainage.
e. Low bearing value.
f. High volume change.

Good Soils

a. Coarse, granular texture.
b. Low moisture capacity.
c. Non-plastic when wet.
d. Easily drained.
e. High bearing value.
f. Low volume change.

It is highly important that the above subgrade characteristics be fully considered and—

4. The design of a broken stone road must be suited to the particular subgrade upon which it is supported.

Influence of Moisture in the Subgrade.—If the percentage of moisture could be kept sufficiently low probably all soils would furnish adequate subgrade support. The difficulty, however, is that some soils such as the clays have an extremely high capacity for water and they are very adversely affected by moisture principally because they are thereby rendered extremely plastic and of low support. It is extremely difficult to drain this type of soil but one of the most hopeful possibilities of betterment in broken stone road design lies in the direction of more effectively ridding the subgrade of excess water. We might set it down as an important principle that—

5. It is highly important that suitable measures be taken to drain away excess moisture from the subgrade.

Possibility of Improving Bad Subgrades.—It goes without saying, that if granular soils furnish good support, and plastic soils poor support, it will be quite possible to improve a bad soil by the admixture of enough good material. The use of an admixture of sand with a clay soil to form a sand-clay road surfacing is a typical example of this procedure and such a surfacing forms an excellent foundation for a broken stone road. The much discussed "stage" construction of the South consists of the building of a sand-clay or top-soil road for the small amount of traffic then to be accommodated, to be followed later with a higher type of surfacing, often a bituminous macadam. The use of a layer of granular material such as fine stone screenings, cinders, fine sand or similar material would also be beneficial for several reasons.

A. Because such a layer would serve as so much more effective thickness for distributing the load to the subgrade.
B. Because such a layer would greatly aid in preventing the upward intrusion of clay into the broken stone layer, thereby preventing its full effective depth from being decreased through lubrication of the stone by the clay.
C. Drainage of the upper layers of the subgrade would be facilitated and the accumulation of capillary moisture in the upper layer would be lessened.

Admixtures of certain materials which might improve the physical characteristics of plastic soils are also not without possibility and are under experiment at the present time by several agencies. A few states have been using a granular sub-bas under their pavement surfaces with very good results.

6. A sub-base of granular material having characteristics listed above for good soils would be beneficial under macadam roads laid on bad subgrades.

From the foregoing discussion it is clear there are certain well-defined lines along which macadam road design might be revived, entirely from the standpoint of improving load-carrying capacity. These changes should aim—

- A. To improve the drainage of the subgrade.
- B. To prevent clay intrusion into the broken stone surfacing.
- C. To increase the load bearing capacity at the edges of the road—
  - (a) By providing greater lateral support at the edges.
  - (b) By decreasing the ratio of subgrade pressure to subgrade resistance.

Macadam Cross-Section Design.—There are certain well-defined lines along which the macadam, or flexible type road, might be revised from the standpoint of improving its load-carrying capacity.

The desired changes should be directed toward:

- A. The improvement of the drainage of the subgrade.
- B. The prevention of clay intrusion into the broken stone surfacing.
- C. An increased load bearing capacity at the edges of the road.
  - (a) To provide greater lateral support at the edges.
  - (b) To decrease the ratio of subgrade pressure to subgrade resistance.

Studies have been undertaken in the cross-section design of bituminous macadam roads to see if the above objects might not be accomplished without an appreciable increase in cost over that of present standard construction. A number of these studies are presented herewith for consideration while a number of other cross-sections which have suggested themselves have been discarded as being either too costly or of very doubtful value.

For the purpose of comparison a so-called "standard cross-section" will be used. This consists of an 18-ft. bituminous macadam pavement having a total uniform thickness of 11 in. with a 3-in. bituminous macadam top, laid on a 7-in. base, constructed in two courses, 4 in. and 3 in. in thickness, respectively. This approximates one of the present state standard cross-sections and with this "standard" as a basis it will be interesting to consider the various forms of cross-section proposed in order to study the probable value of the suggested changes in design. Admittedly, the estimates of costs of these cross-sections are apt to be faulty but are probably close enough for purposes of general comparison.

The First Design.—Figure 4 has as its main features:

The use of a sub-base of granular material consisting of lean bank-run gravel, stone screenings, cinders and like materials which will serve:

(a) To reduce the intensity of pressure on the sub-grade.

(b) To act as a shut-off layer to prevent the intrusion of clay upward into the macadam base.

(c) To reduce the capillary moisture in the sub-grade.

(d) To drain the surface of the subgrade and prevent the accumulation of free water.

This layer is suggested only where the road is to be laid on an exceptionally bad subgrade,

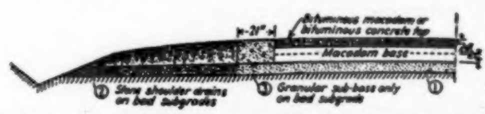


Fig. 4—Proposed Improved Design for Macadam Roads

Features: (1) Use of sub-base granular materials to (a) Reduce intensity of pressure on subgrade. (b) Serve as cut-off layer to prevent intrusion of clay into macadam. (c) Reduce capillary moisture in subgrade. (d) Drain surface of subgrade and prevent accumulation of free water. (2) Use of stone shoulder drains to (a) Stabilize side of macadam against lateral displacement. (b) Prevent breaking down of edges of macadam thus making for greater width. (c) Provide a light colored border thus aiding in night driving. (3) Use of concrete curb to (a) Drain sub-base and subgrade.

and it is presupposed that where such a layer will be necessary for the macadam type it generally will be necessary for roads built of other types. Such a layer probably had better not be less than 6 in. in thickness, although even a thinner one would be of considerable value in preventing intrusion of clay into the stone.

In connection with this layer, wide and frequently spaced stone shoulder drains should be used, for otherwise a reservoir will be created which might actually cause increased softness of the subgrade.

To strengthen the outer edges of the pavement, concrete curbs are provided 11 in. in thickness and 21 in. in width. These dimensions were calculated so that this cross-section would have about the same beam resistance as the concrete shoulders used successfully in the State of Maryland. Such a curb stabilizes the macadam against lateral displacement, prevents the breaking down of the edges of the bituminous surfacing, thus making for greater effective width and provides a light colored border which has been found to be of advantage in night driving. This section has been

reduced from 11 in. to 10 in. in thickness at the center for it is believed there is much more likelihood of the subgrade having higher supporting value at the center than at the sides during critical periods of the year, and moreover, at the center, the load is more widely distributed over the subgrade than near the edges of the macadam. It is estimated that this type of cross-section will cost approximately $5,500 a mile more than the standard cross-section. This additional expenditure

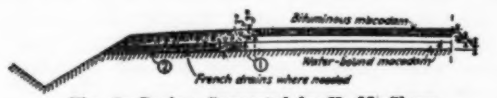


Fig. 5—Design Suggested by H. M. Sharp

Features: (1) Stepped construction at edge better to distribute subgrade pressures. (2) French drains where needed to promote dry subgrade.

is warranted only if a saving in annual maintenance cost of 5 per cent of $5,500 or $275 is effected thereby. Although such a section should require less maintenance to keep the edges in good condition, it becomes a question as to whether or not this saving warrants the extra expense for concrete curbs. It also becomes a question as to how favorably the annual cost of a cross-section of this type would compare with that of other types of pavements suitable for similar conditions of traffic. It is probable that this section would be more expensive in first cost than a suitable section of concrete. The behavior of concrete curbs under severe freezing conditions is also open to some question.

Design Proposed by H. M. Sharp.—In Fig. 5, proposed by H. M. Sharp, formerly Chief Engineer of the Ohio State Highway Department, it will be noted that the first and second base courses are each laid with an extension of 6 in. beyond the course above. Reference to

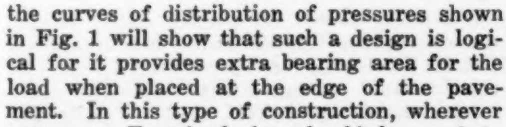


Fig. 6—Proposed Improved Design for Macadam Roads

Features: Use of (1) granular sub-base, (2) bituminous macadam at edges of road using hard bituminous binder throughout depth to increase both vertical and lateral strength at edges, (3) stone shoulder drains to drain sub-base.

the curves of distribution of pressures shown in Fig. 1 will show that such a design is logical for it provides extra bearing area for the load when placed at the edge of the pavement. In this type of construction, wherever necessary, French drains should be used to help insure a dry subgrade. This cross-section is likewise decreased in thickness 1 in. at the center as compared with the standard cross-section. It costs approximately $500 per mile more than the standard cross-section and, in comparison, would have to show a saving in yearly cost of 5 per cent of $500 or $25.00 per mile. There should be less breaking down at the edges on a pavement of this type as compared with the standard type and such a section would very likely be a more economical section than the standard cross-section, also, because of its comparatively low first cost it should compare very favorably with competing types of pavements.

Design Having Penetration Macadam Edges.—In Fig. 6 the essential feature is the use of penetration macadam edges, either in the second base course or throughout the whole depth of the pavement, extending over a width of 21 in. from the sides. The center thickness has been decreased to 10 in. instead of 11 in. as in the standard section. In the case of a bad subgrade a granular sub-base and stone shoulder drains should likewise be provided. Figuring on the basis of a full depth penetration of bituminous material at the sides at the rate of 5 gal. per sq. yd. for the full depth, this section costs approximately $800 per mile

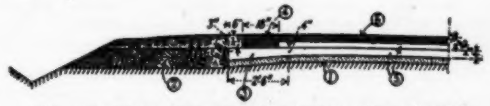


Fig. 7—Design Proposed by Carl L. Van Voorhis

Features: Use of (1) Granular sub-base on bad subgrades, (2) stone shoulder drains where needed, (3) thickened and extended base, (4) bituminous macadam edges in second base course, (5) waterbound macadam base, (6) bituminous macadam or surface treated top.

more than the standard section. If the extra thickness of bituminous macadam is extended only through the second base course such a section would cost approximately $200 more than the standard section. It would seem that considerable benefit might result through the stiffening effect of the bituminous material applied either through the full depth or part depth at the edges of the road. Variations in this design can well be worked out to very good advantage and in Fig. 7 such a design, proposed by Carl L. Van Voorhis, Chief Engineer of the Ohio Crushed Stone Association, is shown. Note that in this design use is made of thickened and extended edges in the base course, and the bituminous penetration is extended through the second base course at the sides. This section would cost approximately $100 more than the standard, but has features which recommend it as an improved design.

A Section That Offers Interesting Possibilities.—In Fig. 8 is shown a type of construction which has been included in these studies as a

section which offers interesting possibilities. Notwithstanding its very radical features it should be well worth building experimentally. The proposal is to construct the various courses of broken stone as they would normally be constructed with the exception that the first and second base courses would be filled with screenings only over part width instead of full width, thus leaving a narrow strip of unfilled stone at the sides. After rolling of the three courses is completed, it is proposed to pour the side strips not quite full of calcium chloride-accelerated Portland cement grout in the proportions of 1:2, thus forming a grouted-in-place concealed concrete curb of the cross-section shown. Later the bituminous macadam course would be poured and finished in the usual manner. It is felt that such a curb would greatly add to the vertical and horizontal stability of the pavement at the edge.

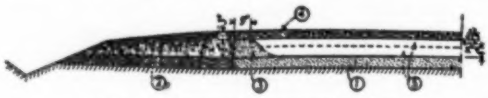


Fig. 8—Proposed Improved Design

Features: Use of (1) Fine granular sub-base on bad subgrades, (2) stone shoulder drains where required, (3) portland cement grouted curb to strengthen edges, formed by filling voids either with liquid grout or dry cement-sand filler, (4) bituminous macadam top, (5) waterbound macadam base.

In time it probably would crack transversely at frequent intervals and would then act in practically the same way as large hand placed stones held firmly in position. Considerably increased support of the pavement edges should result both vertically and laterally. The cost of the grouting would be, roughly, $1,300 per mile, and the net increase in the cost of this section over the standard cross-section would be approximately $700, a yearly increased cost of $35.00 which would have to be saved through decreased maintenance. Where bad subgrades are encountered, a granular sub-base and stone shoulder drains should be provided also.

The use of Portland cement grout along the edges has some disadvantages, chief among which are (1) the necessity for having extra equipment on the job, such as a grout mixer and its appurtenances, (2) the uncertainty of the desired degree of penetration of the grout and, (3) the necessity of subjecting the grouted edge to the weight of the roller during the rolling of the bituminous macadam top.

Method Proposed by R. W. Colburn.—A more practical and more economical method than the above has been suggested by R. W. Colburn, Construction Engineer of the Massachusetts Highway Department. It consists of using a dry mixture of Portland cement and sand as the filling material in the stone base course or courses and depending either upon artificially or naturally applied moisture to set up the cement. This method was tried by the writer on a small scale. Unquestionably such a method would add to the strength of the edges of a bituminous macadam pavement and the expense would not be unreasonable, probably not over $1,000 per mile for the formation of curbs. Taking into account the decreased cost of this section due to the use of less stone in the center the net increase would then be about $400. This idea of using a dry filler of cement and sand or cement and stone screenings along the edge is most certainly worthy of a practical trial.

All of these sections should require less maintenance expense because they are strengthened along the edges where the present design is weakest. Generally side breakage is progressive and is due to the lack of support offered by the base. With all of these sections decreased pressure intensity on the subgrade at the edges should result because of a better distribution of the loads, and in Figs. 4, 6, 7 and 8 lateral restraint is likewise provided. Also the use of shoulder drains and a granular sub-base under all sections on bad subgrades should increase the load resisting value of the subgrade.

The foregoing studies in cross-section design have been made for the purpose of improving the bituminous macadam road type so far as its ability to carry loads is concerned. All of these sections seem to hold promise of giving better service than the standard design, and where the cost is not materially increased it would seem that these revised sections are certainly worthy of a practical trial. There are here presented in order to stimulate further thought on the part of engineers to the end that finally there will result a design for bituminous macadam which will serve traffic at a lower yearly cost than present roads of this type. It is urged that highway departments give all of these ideas a thorough trial on short stretches in comparison with their present standard bituminous macadam cross-sections.

A New Tracing Paper

An improvement in tracing paper is announced by the Special Paper Manufacturing Co., 96 Reade St., New York City. The company is now putting out a vellum prepared tracing paper, Frenchvel, that is white and odorless. It is further claimed that the paper does not turn yellow with age nor does it become brittle. The manufacturers will send free a 2-yd. working sample on request.

Strengthening Old Metallic Bridges

English Methods of Using Reinforced Concrete Described in Paper Presented Before Engineering and Architectural Section of Royal Sanitary Institute Congress

By T. H. BRYCE and T. J. GUERITTE

Many bridges built during the last century, of cast iron, wrought iron or steel, have become inadequate to carry modern traffic, mainly owing to the increase in weight and speed of moving loads and to the narrowness of the bridges themselves.

It has been found desirable in many cases to scrap the old bridge and erect a new one, stronger, wider and with suitable approaches.

But there are many occasions when it is possible and advisable to repair, strengthen and if need be widen the old structures. First, because some have become historical, as, for instance, the Telford bridges, commemorating the battle of Waterloo. Secondly, because some are graceful, and worthy examples of the engineering skill of those times. Thirdly, because some have become, so to speak, part of the landscape. Fourthly, because an important saving may be secured by judiciously chosen methods of strengthening, as well as a saving in time, and because strengthening can be carried out with less interference with traffic than would be necessitated by a reconstruction.

First Application of Ferro-Concrete to Strengthening Work.—As far as the authors are aware, the first application of ferro-concrete to such strengthening was carried out for the Paris-Orleans Railway of France by the firm Hennebique, in 1900, for a straight girder bridge at Perigueux, span about 26 ft., width 13 ft. The two main girders were of the lattice type; the tranverse secondary beams were compound I section and supported a wooden decking. The ironwork of the bridge, which stands just outside the railway station, had been considerably eaten away by the blast of smoke and cinders from the engines. The repairs were carried out by embedding the steel work in concrete and providing extra reinforcement in the shape of round bars and stirrups. The timber decking was replaced by a ferro-concrete decking acting as top flange of the renewed beams and giving a monolithic character to the ensemble. The tests after strengthening were satisfactory, and Continental engineers began to utilize the method. But generally the old metal was merely used, so to speak, as a support for the shuttering of the reinforced concrete work, which was calculated to take the full stresses. Little account was taken of the old metal work in the general work of resistance. Whatever additional strength it would give to the new ferro-concrete structure was considered merely as an increase in the factor of safety.

The reason for this was that the adhesion of concrete to the smooth and flat surfaces afforded by rolled-steel girders or even compound girders, is not found to be so good in practice as that obtaining between concrete and round bars of the sizes usually employed in ferro-concrete work. It was difficult therefore to ascertain how the old metal members would work. And, on the other hand, it was difficult to create a satisfactory connection between the old metal work and the new steel reinforcement, and to ensure that the two would work together.

Nothwithstanding the good results obtained in practice on the Continent, those difficulties seem to have acted as a deterrent to British engineers, and, although the pioneers of ferro-concrete in this country submitted several schemes of strengthening to the latter, for many years after 1900 no actual application of the process was seen in this country.

A number of bridges of the London, Brighton and South Eastern and Chatham Railways which had suffered from corrosion, had their metallic girders encased in concrete from the year 1908 onward, and thereby gained strength and a renewed lease of life, but no additional steel was used, nor any attempt made to render them suitable for carrying greater loads.

Adoption in England. — The first real strengthening known to the authors in this country was carried out in 1917, as the result of an accident happening to a Telford bridge built at Stokesay (Shropshire) in 1822. The then county surveyor, Major A. T. Davis, M.Inst. C.E., was very desirous of retaining undisturbed, if at all possible, the external appearance of the old bridge, which had a span of 55 ft. and a width of about 21 ft. It consisted of four arched girders cast from so-called No. 2 Shropshire iron (according to Telford's specification) 1 ft. 6 in. deep at the center and 7 ft. 6 in. at the abutments. These were all 2 in. thick, cast with openings which left the upper and lower ribs and vertical bars 4 in. wide. Each girder was cast in two pieces, meeting at the center and firmly se-

cured together by a grated cross piece with bolts. The foot of each girder was secured in the socket of the springing plate by wedges and iron cement. The decking consisted of ⅞-in. thick cast-iron covering plates.

Under the stress of modern traffic a considerable number of fractures existed in the bars (especially near the haunches) for the two internal girders. It may be said that for a distance of about 8 ft. from the springing line, the lower rib, 4 in. by 2 in. section, was practically severed from the remainder of the structure, and the fact that the bridge stood was due to the high quality of the cast iron (from the Coalbrookdale Company). The external arches exhibited no fractures, the load coming upon them being negligible.

Major Davis, in collaboration with Messrs. L. G. Mouchel and Partners, of Westminster, strengthened the work as follows:

To the internal ribs were added a number of round bars running, some, along the full length of the intrados, others, along the intrados and then rising towards the extrados in the direction of the abutments, others running along the full length of the extrados. Vertical links of round steel connected the intrados to the extrados, and the whole of the new steel and cast-iron work was ultimately encased in Portland cement concrete. The cast-iron decking plates, the road surface and the handrailings were not disturbed, as they were in good condition.

The general appearance of the bridge was hardly affected. The tests were carried out with a moving load of 30 tons on a 10-ft. wheel base and were very satisfactory. The cost was less than £6 per sq. yd. covered, which is considerably lower than the cost of a new bridge.

This encouraged Major Davis to proceed with the repairing and strengthening, on similar lines, of another Telford bridge constructed at Cound, in the year 1818, and very similar in design, the span being identical, the width being 18 ft. The cast iron from Hazeldine's foundry, Shrewsbury, was of excellent quality. The internal, weight-carrying ribs were cracked in a precisely similar manner to those of Stokesay, but to a greater extent.

Messrs. L. G. Mouchel and Partners' working details were very similar to those of Stokesay. The road surface was not interfered with, and the traffic never stopped over the bridge, although the vehicular traffic, temporarily restricted to 5 tons in weights, was ordered to cross at reduced speed.

Widening an Old Iron Bridge.—Encouraged by the good results obtained, the county engineer for Carnarvon, D. R. Perry, carried out in 1922 a design prepared in 1910 by Messrs. Mouchel and Partners for the well-known bridge at Bettws-y-Coed, the bold letters forming part of the cast-iron ribs of which declare that "This arch was constructed in the same year the battle of Waterloo was fought."

The span is 105 ft., the width 20 ft., the rise 10 ft. 6 in. The depth of the five-arched girders at the crown was 3 ft. (exclusive of road material), and 13 ft. 6 in. at the haunches. The bridge was widened to 28 ft. clear, the total width of the decking being 30 ft. The provision of the two cantilevers 5 ft. wide on each side of the bridge necessitated the entire reconstruction of the decking, which was made in ferro-concrete with transverse beams 4 ft. apart, the ends of which acted in cantilever.

To keep the bridge open to traffic, the work was carried out in two operations, leaving at first one-half of the old bridge open, say a roadway 10 ft. wide. This interfered with the strengthening of the central rib, and as it was desired to keep the external ones (which have the historical lettering) absolutely untouched, the solution adopted was to strengthen considerably the two intermediate ribs and to make them sufficient to carry the greater part of the load. Their scantling became 2 ft. 4 in. by 3 ft. 6 in., the spandril walls above them being solid ferro-concrete, 6 in. thick. The central rib was somewhat strengthened during the construction of the second half of the bridge. Notwithstanding the presence of the overhanging widening, the general appearance of the bridge was well preserved. The test load consisted of 40 tons on four wheels with 13 ft. from axle to axle. The cost was about £5,000 an important saving again upon that of a reconstruction.

Another Telford bridge at Tewkesbury was strengthened by the help of reinforced concrete in 1923, B. C. Hammond, Assoc.M.Inst. C.E., county engineer, Worcester. This bridge is an arched rib structure 164 ft. span. The cast-iron plate flooring was replaced by a strong reinforced concrete floor, which distributed the loads over a greater area, and thereby secured co-operative working of the various ribs, which previously were practically independent owing to their transverse, bracing being almost negligible. No attempt was made, however, to strengthen the ribs themselves and thereby allow the bridge to take full Ministry of Transport loads.

Adhesion of Concrete.—In strengthening Stokesay, Cound and Bettws-y-Coed bridges, the difficulty previously mentioned was encountered. Little advantage was taken of the presence of the cast-iron members in computing the strength of the repaired and strengthened work. One would not rely upon the adhesion of concrete to the smooth surface of the cast iron; means had not yet been found to repair by welding the fractures of such cast iron with any degree of security;

and repairs by sleeves and bolted plates were equally out of question owing to the difficulty of drilling in such small cast-iron members. The same factors militated against a proper connection being secured between the cast iron work and the additional steel reinforcement.

In a heterogeneous material like ferro-concrete, the harmonious working of two materials having such a widely different modulus of elasticity as concrete and steel is rendered possible only because one knows that one may rely within known limits upon the adhesion between the two materials. If a third element is introduced—viz., cast iron, with still another different modulus of elasticity, and which does not adhere properly to concrete, special means must be found to force it to work concurrently with the steel.

The consideration of those difficulties led M. de Boulongne of the Paris, Lyons and Mediterranean Railway, to devise a new method of securing such results. The single track cast-iron railway bridge at La Voulte built in 1861, had become insufficient, if not unsafe, for modern traffic. It comprises five spans of 180 ft. each with four ribs to each span. Many members had become fractured and some of the bracings had even entirely disappeared. The cost of an entire reconstruction being prohibitive, it was desired to ascertain whether a reliable strengthening could not be secured at less cost. The company "Soudure Autogene Francaise" being urged to improve the process of welding cast iron, succeeded in doing so, and many fractures were thus repaired during the process of strengthening.

Means were adopted for thoroughly knitting together the new steel work and the cast-iron members. The following details were given by M. de Boulongne at a meeting of the British Section of the French Society of Civil Engineers, London, 1924.

The damaged cross braces were replaced first by steel frames, which, while ensuring proper bracing, were not so rigid as the original cast-iron ones, the too great rigidity of the latter having caused many fractures. All the fractures in the ribs were repaired by arc welding, by deposit of metal along the lips of the fracture, and, when necessary, by addition of short steel bars, square or rectangular in section overlapping the broken part and welded to the old metal for their whole length.

Then a continuous ferro-concrete intrados was constructed right along the lower flange of the ribs. A similar ferro-concrete slab was provided at the extrados for a length of 21 ft. from each springing. A number of transverse spandril frames were provided so as to give transverse stability. And the old flooring carrying the railway track was replaced by a ferro-concrete one, with longitudinal and transverse beams distributing the load as equally as possible between the four ribs.

The strengthening of the lower flange was affected by means of longitudinal rods, solidarised every 8 in. by means of smaller rods, the latter going through holes provided in the web of the voussoirs, and strongly wedged into them. After going round the big bars they are tied to the bars of the intrados slabs.

In cases when the knitting cannot be secured through welding in drilled holes, spot welding may be advantageously resorted to. The result thus obtained is twofold, the steel work is thoroughly connected with the cast iron, and the concrete which ultimately encases the metal cannot slip along the voussoir. The ends of the main reinforcing bars are tied to the springing plates of the ribs, screw unions ensuring that every stress to which the cast-iron work is subjected will be shared by the steel work. The intrados and extrados slabs are, generally speaking, 4 in. thick and reinforced in the orthodox manner by two layers of rods. each layer having both longitudinal and transverse rods. The slab under the permanent way was designed also in the orthodox manner. The traffic was never interrupted during the operations; the rail level had been raised 2 ft. to facilitate operations; and was left permanently at the new level. Previous to concreting, the whole cast-iron work had been sand-blasted, to ensure better adherence of the concrete. Under the passage of a train with three "Pacific" engines, no appreciable vibration was felt.

Costs.—The cost of the repairs was less than half the estimated cost of reconstruction, and the desired result of preserving the general appearance of the original bridge was fully attained.

An argument against the strengthening of old bridges, and in favor of their replacement by new ones, was that modern traffic requires wider roads. It was considered impossible to widen old cast-iron bridges. But the examples of Holt Fleet Bridge to be widened from 20 ft. to 24 ft., and of Bettws-y-Coed widened from 20 ft. to 28 ft. clear, show that the fear is illusory.

Were it not desired to keep the external appearance undisturbed, it would be possible to increase the widening further still by greater strengthening of the external ribs, and the saving on the cost of reconstruction would still remain high. The method therefore should receive more consideration from engineers in this country than in the past. Heed should be taken, however, of the warning uttered by M. de Boulongne: the strengthening of a metallic structure, and particularly of a cast-iron one, by means of ferro-concrete, requires considerable experience and care, the details having to be gone into very minutely

owing to the presence of the three constituting elements: cast-iron, steel and concrete. Years of experience in reinforced concrete construction, although essential, do not relieve one of the necessity of adjusting one's ideas to the new factors, and the process of adjustment can only be slow; and years of experience in the design of metallic structures go even a shorter way on the road to success for such strengthening work, if it is not coupled with gerat skill in the handling of ferro-concrete problems.

As regards the actual carrying out of the designs, even greater care than is required for ferro-concrete work is essential, and both the contractor and his forman should understand thoroughly the special difficulties of the work, and be highly conscientious.

Concrete Highway Trestle

Semi-Precast Monolithic Structure Described in The Military Engineer

By S. B. MOORE
Captain, Corps of Engineer's Reserve

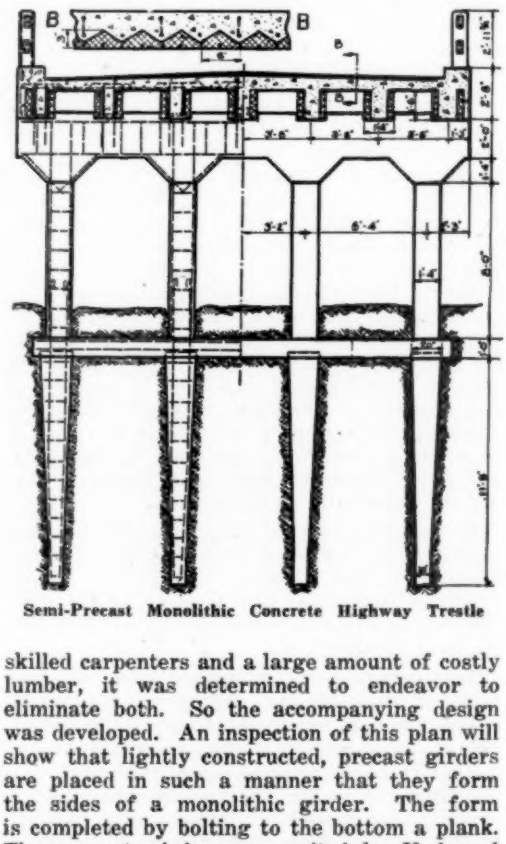
The Texas Highway Commission, in an endeavor to lower the cost of drainage structures built a concrete trestle on somewhat novel lines. In the work some wide departures were made from established practice.

The bridge selected for this work was some 11 miles from the loading point and in a black land district which, in wet weather, is a veritable quagmire. To haul heavy precast concrete piling, ponderous pile driving equipment and fuel over bad roads, frequently impassible, and then conduct operation in a bottom that overflowed even from moderate rains, was considered impracticable. Another consideration was the securing and keeping of skilled labor in such a location. It would be difficult, to say the least, and there was certain to be some dissatisfaction with consequent inefficiency.

It was, therefore, determined to pour the piling in place, and dispense with the heavy equipment and practically all of the skilled labor. Two husky men were selected and given a common 10-in. post-hole augur. It required less than two hours for these men to sink a 10-in. hole 15 ft. in the ground. A 10-in. water bucket was then suspended well towards the bottom of the hole and the hole reamed, the water bucket catching the reamings and being drawn out and replaced as necessary. The hole was reamed out to 20 in. in diameter at the top and was tapered down to 10 in. toward the bottom.

Where hard material was encountered, a drop augur was substituted for the post-hole augur. While the drop augur was slower than the post-hole augur, blue marl was penetrated with little difficulty. As soon as the hole was complete, the reinforcement was placed therein and the concrete poured. Tests were made of the supporting power of these piles, but no settlement could be detected under a loading of 30 tons. These poured-in place piles, coming only to the surface of the ground, were extended by the use of standard forms and then capped. This method of constructing concrete piling reduced the cost from a statewide average of $4.17 to $1.60.

As the construction of a deck under ordinary methods involves the use of highly paid



Semi-Precast Monolithic Concrete Highway Trestle

skilled carpenters and a large amount of costly lumber, it was determined to endeavor to eliminate both. So the accompanying design was developed. An inspection of this plan will show that lightly constructed, precast girders are placed in such a manner that they form the sides of a monolithic girder. The form is completed by bolting to the bottom a plank. The precast girders are united by V-shaped members, laid with the point up, that form the bottom of the slab. The floor slab steel is then laid in the troughs formed by the V-shaped members. The deck is then poured in the usual manner. These departures from standard designs have resulted in reducing the cost of concrete trestles from over $100.00 per running foot to approximately $60.00 per running foot.

Each bent in these bridges contains four piles, each capable of sustaining safely 20 tons, or a total of 80 tons.

Future Bids and Profits

Changes That May Come in the Construction Industry Outlined in The Constructor

By CLARK R. MANDIGO
Executive Secretary, Kansas-Missouri Contractors Association

The general contractor should not want to "kid himself" into believing that the good old days of occasional high profits are ever to return. He must recognize the trend of the times and adjust his business accordingly. The years to come will be years of enormous amounts of construction work in this country. Although in the immediate future the pains of over-production of construction plant will be felt as well as the over-production capacities in other industries. This growing country will, however, soon catch up with these capacities, but by that time the successful construction business will have been adjusted to the new era.

Trend of the Times.—An engineer before stating conclusions, examines the forces acting. Some of the influences which will change the nature of the construction business may very briefly be stated as (1) Restriction of immigration; (2) Growth of education; (3) Increased knowledge of raw materials; (4) Increased scientific knowledge of structural designs; (5) Increasing magnitude of construction projects; (6) Growth of population. There are other forces more or less related to the ones enumerated, but a brief discussion of the influences of those mentioned on the construction business will be sufficient for purpose of illustration.

The restriction of immigration and the growth of education combined are gradually eliminating the common laborer who in the past has been the backbone of the construction industry. This country is permanently committed tö restriction of immigration, and even if world conditions became favorable to large supplies of cheap labor, we will never again see the inflowing hordes of the past, in fact, restrictions on immigrants are much more likely to be increased than relaxed. In the meantime every effort is being exerted in this country for the public education of all children. Schooling is being extended at a rapid rate; laws are being passed and enforced, keeping the child in school; parents are sacrificing everything to give their children a better and longer education than they themselves enjoyed, while cheap, easy, and new means of communication are developing tastes for better living standards and wiping out ignorance. It is obvious that all of this will, in the course of time, give a surplus of white collar men and a dearth of applicants for that class work, which in the past, has been done by those with "strong backs and weak minds." To the contractor this means higher wages, higher than have even been paid heretofore; the substitution of machinery for men wherever possible; better living and working conditions for the men; and a more intelligent, dependable working force if properly handled.

Increased knowledge of raw materials will bring into use many materials not now considered suitable for construction work. It will make possible the manufacture of many substitutes for materials now in use. The constructor must, therefore, be prepared to handle a far greater variety of materials, in a far greater variety of ways, than he now thinks possible.

Structural Design.—The theory of structural design is far from the exact science it is destined to become. Buildings, bridges, pavements—that were considered bold or radical in design only a few years ago, are now back numbers. Our knowledge of the adaptability and strength of construction materials is increasing so rapidly that engineers and architects are able to utilize materials with great economy, but the surface has only been scratched. The future designs will be lighter, more novel, more complicated, and more economical of materials. The constructor to keep pace with this progress in design will have to use his head to a greater extent than ever before in devising the easiest, cheapest, and most rapid ways of putting up these structures.

As civilization grows more complicated; as our standards of living rise; as inventions open new necessities and desires, so will the amount of construction grow. Construction work must likewise keep pace with increase of population. These things will require more intensive development of all of our resources and large investment of capital in industrial plants, business houses, power and transportation developments and housing conditions. Mammoth construction projects which have not been possible in the past because of lack of capital,

or lack of possible return on the investment, will be in the forefront.

Effect Upon Construction.—How will this trend of the times affect the construction business? The successful contractor will be a specialist rather than the jack of all trades he frequently is now. Compelled to pay higher wages than he has ever thought possible, he will be forced to substitute machinery to an extent not now realized. His capital investment in plant will be so greatly increased so that he cannot afford, in most cases, to organize for the construction of more than one class of work. A greater number of materials to handle, and the more complicated designs of construction will simply multiply the necessity of higher wages for the most skillful men and more complicated equipment. This development will mean, in the course of time, at least semi-permanent construction plants where most of the concrete mixing and many other operations now done on the job will be accomplished. The equipment while more costly, will be more standardized, more durable and of greater capacity. There will be much new machinery to increase the production capacity per man, and also very greatly reduce the number of men employed. The successful contractor will have a permanent organization of technical and skilled men all highly paid. He will be obliged to spend more money on investigating, estimating, planning and organizing jobs than has been economical in the past.

Prospects in Outline.—Above all, the future contractor will be obliged to know the cost of all operations, and of doing business more accurately than has been customary or even necessary in the past, because his profits will be smaller. He must be satisfied with an average net return of 10 to 15 per cent on the money he has invested in business, rather than that percentage on the gross amount of work done. He must be prepared to take work in his specialty wherever offered and develop the maximum volume per unit of organization in order to get the fullest productive capacity from his plant. Competition will be close and keen and profits small according to present day standards, and every angle of the business must be watched with eagle eye. The increasing magnitude of jobs offered will necessitate the most thorough going business organization, and to make this possible the most successful concerns will do an enormous quantity of work yearly. Contractors are engaged in a manufacturing business and it behooves them to take the principles of operation of successful factories as examples by which to shape their own line of action. Overhead costs will be greatly increased, but will be justified by the saving made by the elimination of many lax methods of the present day and by greater volume of work handled.

Of course there will be small jobs and small contractors, and some will make a living as always. A few with greater aptitude will rise to a measure of success to take the place of those who through lack of executive ability, attention to business, and vision, are forced to drop out. The mortality rate will always be high.

As is true in every other industry, so in the construction industry, the relationship between contractors themselves, between the contractor and his clients, the material producer, the employe and the public, will always present problems that will require attention. Attacking these problems can be effectively done only by strongly organized trade associations, such as the Associated General Contractors of America. The contractor who will not support his own trade association by his membership will be considered a Pariah. Even the strong association such a membership presupposes cannot make conditions ideal.

It is possible that day-labor construction cannot be entirely eliminated although every blow struck at this wasteful method will be a benefit to the legitimate contractor. The irresponsible bidder cannot be ruled out of business entirely although his activities can be curtailed. Corrective legislation must be passed and present laws bettered. All of this will be of inestimable benefit to the industry as a whole in bettering internal conditions and cleaning up external contracts. In fact, more intensive efforts than heretofore will have to be made to put the construction industry on a thorough going business basis. There will be so many fields of activities, so many ways of co-operation, so many corrections to be made on external and internal conditions, that a large powerful trade association will be an important asset in the business. The contractor, however, will have plenty to do to keep his business progressing, and must not take the attitude of thinking that others can do all the things that are needed.

Perhaps this is more of an opinion than a prophecy. The hue and cry regarding low bids, the pessimistic utterances which have been common among contractors, call for little sympathy—conditions are very likely to "get tougher" as time goes on. The way to beat the low bid game is to reduce costs, increase volume and be satisfied with smaller profits. The successful contractor will be a man of high intelligence and of a character peculiarly adapted to this class of business. He will pay higher wages, higher prices for materials, and at the same time do work at less cost than ever before. The world will only owe him a living if he has this ability to render

it the service it is entitled to have. The present day contractor who recognizes the trend of the times will have that much of a start on the one who does not seem to know that construction is getting to be a complicated business industry requiring the best—the best men can give it.

Just don't "kid yourself" into thinking that anyone else is going to look out for you.

Contractor Moves a Railroad to Build a Highway

It is said that Federal Interstate Highway No. 19 through Fayette County, West Virginia, will, when completed, be one of the most scenic highways East of the Rocky Mountains. It will be one of the principal north and south routes and will afford Pittsburgh with its most direct route to the south, by way of Uniontown, Penn., Morgantown, Fairmont and Clarksburg, W. Va., and will connect with the Midland Trail and the Atlantic and Pacific Highway at Gauley Bridge, W. Va.

Its construction presents many very difficult engineering problems which are being solved by H. R. Anderson, Division Engineer, and H. D. Heal, Resident Engineer, for the State Road Commission of West Virginia.

The new road will parallel the Gauley River and the New York Central Railway Lines and in order to make way for the highway it was necessary to shift the tracks of the New York Central. This necessitated the excavating of 100 per cent hard sandstone. A. Keathley, contractor of Charleston, W. Va., who has the contract for grading 10 miles of highway No. 19, has solved the excavating problem on his section in a rather unique manner. He is using a Bucyrus 70-C for the excavating of the rock and is side casting it over the railroad tracks, without interference to traffic on the railroad. The material is then rehandled by an Osgood ¾-Yd.. heavy duty continuous tread steam shovel and is cast alongside the west bank of the Gauley River.

It is stated that the contractor by this method has been able to handle 14,000 cu. yd., of material in one month. The total excavation on his section of the work amounts to 240,000 cu. yd.

Method of Excavating for Shifting Railroad Track

City Liable for Misrepresentation in Plans.—In the case of Pitt Construction Co. v. City of Alliance, the United States Circuit Court of Appeals, in reversing the lower court, held the City of Alliance to be liable in damages to a contractor on the ground of substantial misrepresentation, where there was a substantial variation between the showing on the plans and the actual facts as to the location of a structure with reference to the existing ground surface, thus entailing a substantial additional expense in making backfill.—Bulletin Ohio Contractors Association.

Checking in Green Concrete

Causes of Surface Cracks Outlined in Badger Highways

By T. J. VITCENDA
Materials Engineer, Wisconsin Highway Commission

A source of concern in all concrete pavement construction during the hot days of the summer season are the fine hair-cracks which sometimes develop in newly laid sections of the pavement. These cracks are very fine, irregular and comparatively short. The true hair-crack seldom has a depth of more than a sixteenth of an inch. When they occur they are found in quite large numbers along a few sections of the pavement laid during the day. They generally begin to show about the time when the concrete obtains its final set, or about five to six hours after the time when the concrete has been poured. From that time until the pavement is 24 hours old the hair-cracks, or checking, will develop very rapidly. Very infrequently does checking occur after a pavement is more than a day old.

The checking of a concrete pavement does not cause a serious decrease in the strength or life of the pavement. In fact, it would be hard to prove that any real harm results because of the cracks. However, an ugly sight is presented wherever considerable checking occurs. When the cracks are later tarred to prevent water from seeping into the concrete, a network of tar strips is left to greet the eye of the traveler.

Causes of Checking.—A number of reasons for the checking have been advanced from time to time and a few are here enumerated. In the first place, it should be understood that a mass of concrete shrinks in drying, and swells as it absorbs water. The total range in linear change from dry to wet conditions is, for common mixtures (say about 1:2:4) approximately one-twentieth of one-tenth of 1 per cent. A mix richer in cement will experience greater changes, while one leaner in cement will show less change. Any condition which will cause one portion of the road surface to dry more rapidly than the adjoining portions will effect checking in the more rapidly dried part. The more important factors in producing non-uniformity in drying are:

1. Non-uniformity in the mixture. This may be caused by improper mixing in the mixer, which will result in variation in the consistency and in the richness of different portions of the batch.
2. The use of too much water in mixing, which is likely to produce variations in the consistency of the mass.
3. A prolonged working of the surface of the road, thus bringing to the top a rich mortar of fine sand which will shrink more than the leaner concrete beneath it as drying progresses.
4. In cool weather, and with cements which are slow in hardening, the rapid evaporation by dry wind.
5. Rapid drying due to direct exposure to the sun's rays.
6. A dry subgrade of variable absorptive capacity, or a subgrade which swells materially when wetted.
7. The use of an aggregate which contains particles varying widely in absorptive capacity. For example, in one instance it was reported that a limestone aggregate caused shrinkage cracks, whereas the use of a gravel under exactly similar conditions did not produce this effect.
8. The use of dirty aggregate.
9. The use of a very quick settling cement.

Any one or several of the above may be contributing factors in the checking of a pavement. In most cases several of the causes listed above work together to form the hair cracks. Probably the most important contributing factors in checking are the first three listed. It is doubtful whether No. 7 is as important as our first thought might lead us to believe. No. 6 may exert a considerable influence in some localities. The only protection against checking is the elimination of such factors as are under control of the engineer. Sometimes the elements play a part and it is practically impossible to take any corrective measures.

Delivering Concrete Mix at 20 Miles Per Hour

To expedite the work and cheapen the cost, Gutleben Brothers, contractors for the State of California on the Rio Hondo bridge on Whittier boulevard, Los Angeles County, have constructed a motorized outfit for delivering concrete mix.

A second-hand Ford automobile with the wheels and body removed was fitted with flanged wheels for operation on an industrial railroad. A riveted sheet steel hopper took the place of the body for carrying the concrete. The mixer dumped directly into the hopper and the driver stepped on the throttle and the load was quickly delivered to its distination on the bridge.

A lever near the driver's seat made it possible to release the mix on either side of the hopper as desired. The speed at which a load of fresh concrete could be delivered made the apparatus very effective, in the opinion of the contractors.

Solving a City's Traffic Problems

How Schenectady, N. Y., Plans to Make the Most Efficient Use of Its Present Street Facilities

By EARL J. REEDER
Engineer, Public Safety Division, National Safety Council, Chicago

"How can we obtain safer and more rapid movement of our traffic with our present street layout?" This is a question which cities all over the country are asking. This was the problem which the people of Schenectady, New York, put up to the Public Safety Division of the National Safety Council for solution.

Such questions as that asked at the beginning of this article are not to be answered without knowledge of many facts regarding present local traffic conditions, street layout and existing traffic rules and regulations. The people of Schenectady recognized the need for a comprehensive study of the problem and urged the quickest possible solution. A new traffic ordinance was proposed into which it was desired to incorporate those desirable rules and regulations which should result from such a study. No time was to be lost.

The Problem.—Under the direction of the writer an intensive survey of existing conditions was made. Recognizing the need for early action and realizing that in the opinions and beliefs of the people of the city lay many of the important facts regarding the problem, the first step was to obtain from representative persons of all classes statements of opinion as to what constituted Schenectady's real traffic problem. Then from these opinions combined

Fig. 1—Proposed Through Traffic Routes for Schenectady, N. Y.

with many personal observations, a statement of the problem was framed. This statement divided itself into two essential parts, viz:

1. To distribute the traffic movement so far as practicable by diverting unnecessary traffic away from the congested business district; and

2. To regulate the use of the streets for safer and better disposition of the necessary traffic in this district.

Like many other cities, Schenectady has its full share of narrow, crooked and dead end streets, with the natural flow of traffic in practically all directions through the main business district. Two large industrial plants located but a few blocks from this district add to the congestion and confusion existing at certain times of the day. Again, the city is located on important routes of through motor vehicular traffic in various directions across the state. The present street layout tends to carry this traffic through the congested business district.

Solution of the Problem.—The solution of this problem, developed from this survey and based upon the above statements, involves five major parts, viz:

1. Routing unnecessary traffic around the congested business district by designating convenient alternative routes and, by proper regulation of traffic making their use desirable;

2. Providing simpler parking restrictions that will require less police supervision and will, at the same time, permit of a more normal turnover in the use of the available parking space by persons having business in the congested district;

3. Expediting the flow of traffic on narrow streets by limiting it to one direction and permitting the parking of vehicles on one side only;

4. Providing for a system of progressive, automatic traffic control on the main business street of the city, to keep the traffic moving at an established speed and with a greater measure of regularity; and

5. Inaugurating an elaborate plan of public education in the requirements for greater safety upon the streets, through the voluntary observance of traffic rules and regulations and the practice of safety and courtesy by both motorists and pedestrians.

The details of this solution were submitted to the city officials and the people of Schenectady in a formal report, published complete with illustrations twenty days from the completion of the survey. Some of the details of these recommendations are described here to show their nature and scope.

Routing—Without distinctly marked alternative routes the natural flow of traffic—particularly that from outside the city—is through the business district. Recognizing, however, that unnecessary traffic must be diverted around this district a system of by-pass routes was developed and it was strongly urged that these be distinctly marked.

To further encourage the use of these by-pass routes Union Street, paralleling State Street, the main thoroughfare, was recom-

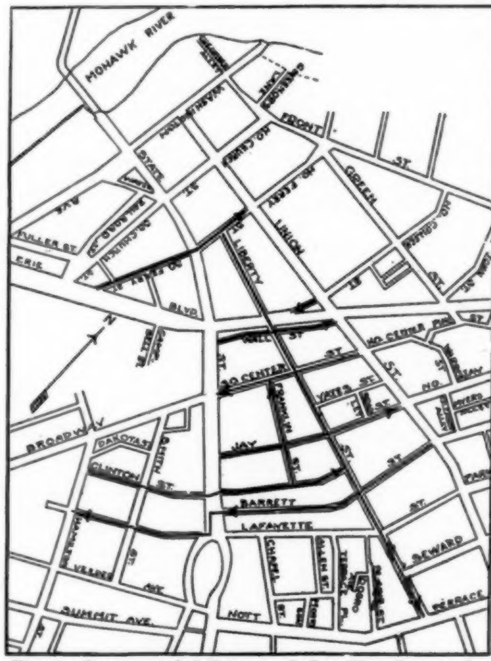


Fig. 2—Recommended System of One-Way Streets for Schnectady, N. Y.

mended to be made a "through street" with proper stop signs and police supervision and control. It was also recommended that other by-pass routes for the use of employees from the large industrial plants be improved by the prohibition of parking at a couple of "bottle neck" points. Figure 1, reproduced from an illustration in the survey report, shows the system of routes proposed.

Parking.—The prohibition of parking in the congested business district of Schenectady is not practical at the present time. However, the "all day parker" has been a big factor in traffic congestion in this city because he has monopolized for the entire day parking space which would otherwise be used for short period parking by a much larger number of vehicles. The most effective way to eliminate the "all day parker" from the business district is to prevent him from parking there when he is placing his car for the day.

Recognizing that it is much easier to supervise and enforce prohibited parking than lim-

ited parking and, also, that there is practically no use of parking space in the business district by shoppers before 9:30 a. m. it was recommended to prohibit all parking in this district between 7:30 and 9:30 a. m., after which ninety minute parking will be permitted for the remainder of the day. The latter restriction can be easily enforced and will preclude the possibility of the half day parker monopolizing the available space to the exclusion of shoppers and others having business in the district during the afternoon. These restrictions can be readily enforced and should provide a reasonably rapid turnover in the use of the parking space.

One-Way Streets.—Schenectady has a number of streets in its business district which are too narrow for a lane of moving traffic in each direction if any parking is permitted. Attempting to allow two-way traffic and one line of parked vehicles has resulted in much confusion and congestion in the use of these streets.

The study indicated the desirability of designating several of these as one-way streets, in preference to prohibiting parking on them. Consequently, a system of one-way streets providing, as nearly as possible, for equal street capacity in opposite directions, was laid out. Such streets must, of course, be properly marked to prevent vehicles from turning into them in the wrong direction. The one-way street recommendation is illustrated in Figure 2, reproduced from the survey report.

Traffic Control.—State Street is a relatively wide thoroughfare through the business district and is the major distributing street for the system of one-way streets described and illustrated above. The need for free and continuous movement of traffic in this street was immediately recognized and a system of "stop and go" lights, installed and controlled to provide for the progressive flow of traffic, was recommended. The irregularity of the street layout complicated this problem somewhat but the system is designed to regulate the flow of traffic at a rate of speed varying from ten to fifteen miles per hour.

Signals were recommended at the intersection of State Street with Washington Street, Church Street, Ferry Street, Erie Boulevard, Center Street, Jay Street, Lafayette Street, Veeder Avenue and Nott Terrace (see Figure 2). It will be noted that these signals are approximately evenly spaced along the street. While there are three intersections at which no signals are located, the flow of traffic as controlled by the signals at adjacent intersections will permit the necessary turns or crossings at these points without interference with State Street traffic.

Traffic control was also recommended at certain points along the proposed through street system, to break the flow of traffic into groups so that pedestrians will have an opportunity to cross at intersections and vehicles will have an opportunity to enter or cross from intersecting streets.

Traffic Safety.—Safety was taken into consideration in all of the above recommendations, as well as in others of less importance that were contained in the report but not listed above. In addition a plan for the education of the general public in the requirements for traffic safety upon Schenectady's streets was recommended.

Not all of these requirements can be incorporated into the traffic ordinance. Some of them must depend upon the practire of ordinary courtesy and plain common sense by both motorists and pedestrians. It is necessary, therefore, to thoroughly acquaint the general public with this unwritten law of traffic safety through extensive educational means. For example, while the control of pedestrian traffic is recommended at those points where vehicular traffic is controlled, the vast majority of street intersections in the city will not have such control and it will be necessary for pedestrians and motorists to exercise care and good judgment for their mutual safety.

The recommended plan includes extensive publicity of traffic rules and regulations and safety requirements upon the streets; safety instruction and activities in the schools and upon the ctiy playgrounds; safety activities among commercial drivers; programs and campaigns conducted by clubs and other interested organizations; and other similar means of reaching the public.

Proposed New Ordinance.—In line with the above recommendations a proposed new ordinance to substitute for the present traffic ordinances was recommended. The standard provisions of model ordinances, particularly the recommendation of the second National Conference on Street and Highway Safety, so far as they applied, were incorporated into this recommended ordinance.

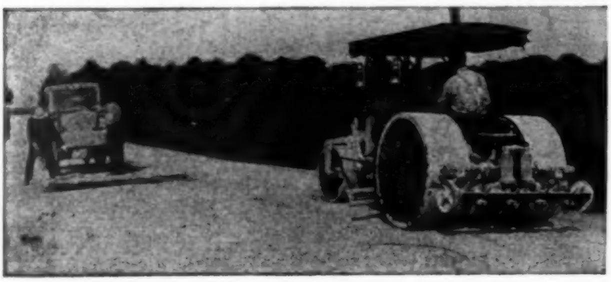
Other National Safety Council Surveys.—This survey, recently completed is the fourteenth community study conducted by the Public Safety Division of the National Safety Council. It represents a slight departure in this field of operation because, heretofore, the surveys have been confined largely to those community problems relating almost exclusively to accident prevention. The fifteenth survey, now nearly completed, will be a study of public safety for the Milwaukee Safety Commission.

Rolling in Surface Treatment

The Lincoln Highway for about 14 miles west of Mansfield, O., is macadam and has just been surface treated with asphalt and limestone chips. The previous surfacing had been with 0.25 gal. of tar and 22½ lbs. of stone to the square yard.

From results secured then it was felt that the proportion of stone could be greatly increased to excellent advantages preventing loss of asphalt oil and giving a better, more substantial surface. Greater losses of chips were of course, expected, but these to a large extent would remain on the berm making a better surface here.

The earlier plans did not include rolling but when the short section in Crawford County was re-surfaced a 5-ton Galion junior roller belonging to Crawford County was used to pack the surface with such excellent results that arrangements were made to use this roller on the entire job.



Spreading Chips and Rolling

Quantities used were 0.25 gal. of asphalt oil and 28½ lbs. of number 4 crushed limestone chips per square yard. Half the width of the road was surfaced at a time leaving the rest of the road clear for traffic. The chips were thoroughly rolled down with the 5-ton roller as soon as placing of them was completed.

Several distinct advantages resulted which satisfied the men in charge of the work that rolling is thoroughly worth while.

In spite of the increase in the quantity of limestone chips, there is less loss when rolled, than with the smaller quantity unrolled.

The ridge which usually occurs in the center when half the road is surfaced at a time is entirely reduced by the roller, leaving an even surface.

The surface of the road is left more even and firm with far less shifting of chips, exposure of fresh asphalt oil and irregularities resulting from traffic than is the case with unrolled surfacing.

From the observation of the surface so far, it is safe to say that the excess of chips and the rolling have resulted in a much better and thicker surfacing and one which will be far more lasting and satisfactory than the previous surfacing and that this and the other advantages mentioned far outweigh the added cost.

This work was done under the general supervision of State Distributor Superintendent John Dalton, who supplied the information given above, assisted in Richland County where most of the work is located, by County Superintendent of Roads T. B. Finney.

The Cost of Traffic Congestion

Traffic congestion costs the United States in excess of $1,600,000,000 annually, or more than the entire expenditure for highway construction on the total 3,000,000 mile system, according to the American Road Builders' Association. The statement was issued by the organization to emphasize the need for wider highly signalized city streets and highways.

Expert statisticians estimated after careful study that the traffic congestion in the city of Chicago alone cost that metropolis $180,000,000 annually, not considering the enormous property loss resulting from automobile accidents which would have been avoided had a free flow of traffic existed. As a result of these conditions a bond issue of $12,500,000 has been issued for the widening of city streets.

The traffic requirements of the United States are such that the immediate widening of roads in and about the large cities is not only economically sound, but essential to the welfare of the people, according to the American Road Builders' Association. It was stated that the cost of traffic delay in the cities is greater than the cost of widening, signalizing and otherwise improving the roads could possibly be.

A session of the annual convention of the Association to be held in Chicago during Good Roads Week will be given over to the study of traffic conditions in the country, it was announced. The meeting will be held January 10th to 15th, 1927, in the Coliseum and Coliseum Annex.

President H. G. Shirley, in announcing the annual meeting for the Association, stated that highways should not only be built to care for the present traffic needs, but should be designed to care for future progress. At the present rate of registration the number of automobiles on our highways will have reached 25,000,000 by 1930, he said.

Snow Removal in Northern Michigan

How 500 Miles of Highway Were Kept Open Described in Address Presented July 21 at Meeting of Northern Michigan County Road Commissioners

By J. T. SHARPENSTEEN
Maintenance Supervisor, State Highway Department

Snow removal for wheel traffic in the northwestern part of the lower peninsula was attempted the first time last winter. At the beginning of this year there was 72 miles of state trunk line on the snow removal program, located on trunk line 11 from Manistee south to the south Mason county line and on trunk line 13 from Cadillac to Reed City. During the month of January funds were made available to include the balance of trunk line 11 from Manistee to Mackinaw City and the balance of trunk line 13 from Cadillac to Petoskey, making a total of 348 miles. In addition to the mileage on these two trunk lines, 136 miles on other trunk lines were kept open by different counties out of funds that had been provided for opening the roads this spring, supplemented in some cases by donations and in others any additional expense over the budget allowance was borne by the counties. There was also some 10 or 15 miles in cities that were kept open by the city snow plows, making in round numbers 500 miles out of 765 miles of state trunk line in the 13 counties comprising this district.

The Local Conditions.—This discussion is based largely on the experience gained during the past winter and the conclusions reached are not offered as being applicable to snow removal in general. The conditions existing in this locality, namely snowfall, wind, temperature, etc., are not characteristic in the same degree of other sections in the lower peninsula, and it may, therefore, be said that methods and equipment used here would not be economical or effective in other sections and, likewise, methods and equipment found successful in other sections would be a handicap in some cases to satisfactory snow removal under conditions peculiar to this territory. There is a marked difference in the conditions existing among the different counties being considered and even on two trunk lines in the same county the snow conditions may be entirely different.

Equipment Available.—The equipment that was available for maintaining the original 72 miles on the program consisted of two 10-ton tractors, two rotary snow plows, two blade type plows mounted on heavy army trucks, equipped with solid tires and two other side delivery plows mounted one on a 1½-ton truck and the other on a 2-ton truck, both equipped with pneumatic tires. The results of the work done with the rotary snow plows were very gratifying. The heavy trucks and blade plows did satisfactory work in the early part of the season, but when the storms had increased considerably in length and intensity this class of equipment proved to be inadequate. Several times these trucks started out at the beginning of a storm and after traveling 6 or 8 miles from headquarters would find further progress impossible and in attempting to return would find the road blocked from behind, making it necessary to send out heavy equipment to release the truck. The two light trucks equipped with the other type of plow performed in about the same manner as the heavy trucks with the blade plows.

About Feb. 1, five new 10-ton tractors and five new rotary snow plows were received to take care of the additional mileage that had been authorized. At about the same time five blade plows were received and mounted on trucks. In addition to this equipment, there was available for use on the added mileage, one county-owned heavy V-type plow and tractor and one or two truck plows.

3 Ft. to 8 Ft. of Snow.—By the time the heavy equipment could be put into operation the snow had reached a considerable depth running as much as 8 ft. with long stretches varying from 3 to 6 ft. To complicate matters this accumulation of snow on the road had been compacted by sleigh traffic and in some cases by rolling with a heavy roller which produced an ice core that was very difficult to remove.

Not having had snow removal previously there was no one familiar with operating a rotary plow and in most cases, experienced tractor operators were not available. This, of course, necessitated the use of "green" crews. Only one or two county garages had doors large enough to permit storing a tractor and plow when not in use and this lack of storage is believed to have contributed very largely to the breakage that was experienced.

With these difficulties to contend with, a

start was made and, to the surprise of many, the roads were opened. There was more or less delay from breakage, which was inevitable, but the plows were kept going night and day as far as possible. After the roads had once been opened the big problem ahead was to keep them open. It was found that the truck plows were of little use except to follow the heavy equipment and clean off any loose snow that was left on the roadbed. Being unable to use the truck plows in anything except very light storms and for the purpose indicated above, it was necessary to do practically all the work with heavy equipment, which is very slow work when attempting 50 to 70 miles with one tractor.

The two light trucks previously mentioned, having been found inadequate, were replaced in the worst part of the season with two 3-ton trucks equipped with pneumatic tires and V-type snow plows. This equipment gave very satisfactory results and relieved the rotary plow of many miles of travel which would have been necessary with the trucks and plows that had been discarded and at the same time the roads were opened much more rapidly and at considerable expense. In another county a 3-ton truck equipped exactly the same as the two just mentioned was put into operation at about the same time, and with the aid of a rotary plow for two or three days was able to keep 40 miles of trunk line open for wheel traffic a greater part of the time for the balance of the season.

Snow Fence.—The greatest aid in snow removal in this territory is the prevention of drifts on the road by the use of snow fence or other means. Two types of snow fence were used. Approximately 9 miles of 4-ft. picket fence was erected and probably about 1½ miles of board fence, made up in sections, was used. In erecting the picket fence, 7-ft. steel posts, spaced one rod apart, were used. The distance back from the road that the fence should be placed caused some worry, but it was finally decided that 100 ft. back of the field fence, or in most cases, 133 ft. from the center line of the road, would be tried. In general, this distance worked very well, but it was learned that the terrain governs the distance very materially. In cases where the ground slopes away from the road to any marked extent, the fence should be placed nearer the road, and in those cases where the ground slopes toward the road the fence should be placed farther away. On level ground, where drifting is extremely heavy, a greater distance from the road is preferable. It was observed in a number of cases that a fence 4 ft. high is not sufficient in the latter part of the season. In those places where drifts can be formed more than 4 ft. in depth it is believed that a 4-ft. picket fence can be employed with satisfactory results by using 8-ft. posts and raising the fence when the conditions warrant on additional height.

Cost of Snow Removal.—There is a popular opinion in a few sections that the cost of snow removal is an extravagant expenditure of public money. A comparison of the cost of snow removal with the cost of maintenance for the balance of the year proves this is an erroneous opinion. A comparison of these costs in six counties, having practically all gravel roads, show that the cost of snow removal per mile per month varies from 19 to 45 per cent of the cost per mile per month of maintenance for the remainder of the year.

It should be borne in mind that the snowfall last winter was unusually heavy. According to newspaper reports, there was 11 in. more snowfall in Grand Rapids than any previous record and in Detroit all existing records were broken. It is safe to assume that the same condition existed in this territory. This fact, together with an insufficient amount of equipment, a late start and the lack of experience, increased the cost of snow removal very materially. There is no doubt that under normal conditions a considerable reduction in cost could be shown.

As might be expected, the service given the public was not 100 per cent perfect. On one 70-mile section, where extremely bad conditions were encountered, the results were far from what was dsired. On another section of 35 miles the road was passable a little better than 98 per cent of the time. A letter received from a bus concern operating over this section stated that its records showed that only one and one-half days were lost during the entire winter. As a whole, snow removal on Trunk Line 11 was fairly successful, however, a few sections of this road were impassable for a number of days on several occasions.

To summarize our conclusion, it seems safe to say that efficient and economical service can be rendered under the following conditions: First, a supply of snow fence sufficient to protect the roads at points where unusually bad drifting conditions exist; secondly, a heavy outfit consisting of a 10-ton tractor and rotary snow plow for each 35 or 40 miles of road; third, a heavy duty truck of 3 or 3½ tons capacity equipped with penumatic tires and a V-type plow for each 15 or 20 miles of road. This equipment, supplemented by other light equipment which is already available, will insure the operation of cars, trucks and busses throughout the winter without interruption except in very extreme cases.

Grading of Sand

Influence on Strength of Concrete Described in Public Roads

By J. G. ROSE
Materials Engineer, U. S. Bureau of Public Roads

In connection with the testing of materials for Federal-aid highway projects in Colorado a study has been made of the relation between the grading of sand for use in concrete and the strength developed in mortar and concrete; and the study has led to the development of a graph which may be used as the basis for a preliminary judgment of the quality of sands proposed for use.

The samples of sand and gravel, or crushed rock, upon which the study was based, were contributed by the state highway department of Colorado as materials to be tested for use on federal-aid projects. Approximately 200 samples of sand and gravel are represented by the study. The source of the materials was widespread, almost every county in the state having contributed one or more samples.

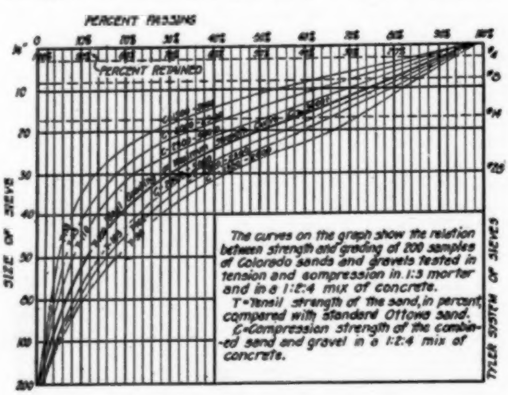


Fig. 1—Sand Analysis Chart

The testing work was done by the Pierce Testing Laboratory, of Denver, and standard methods of testing concrete materials approved by the American Society for Testing Materials were followed in making all tests. Standard briquettes of 1:3 mortar were used for the tensile tests, and 6 by 12-in. cylinders of 1:2:4 mix were used for the compression-test specimens. The consistency of the concrete was such as to show a slump of from 1 to 2 in. as determined by the standard slump-cone method. All observations are based upon the 28-day strength of the specimens, both in tension and in compression.

While assembling the test data for the study it was observed that the strength of the 6 by 12 in. cylinders varied from about 1,500 lb. per square inch to a little over 3,500 lb. to the square inch. In order to observe the variation in grading between the high and low strengths, the test reports were divided into four groups, each group having a range in strength of 500 lb.; and after computing the average grading of the maximum strength group (3,000 to 3,500 lb. per square inch) and plotting this average grading upon the graph, it was observed that part of the reports in the remaining three groups fell above the maximum strength curve, and part fell below it. The three groups were, therefore, divided again into two groups each, depending on whether the grading of the samples fell above or below the maximum strength curve. Samples falling partly above and partly below the maximum strength curve were listed in both groups; and the average gradings for the six groups thus obtained were then computed and plotted on the graph. The groups thus established, according to grading, were then averaged for tensile strength.

What the Graph Shows.—The curves derived for the above averages as shown in Fig. 1 lead to the following conclusions:

1. That there is an ideal grading of sands which will produce maximum strength in concrete.

2. That the ideal grading curve assumes an arched form showing a predominance of the material retained upon the coarser sieves.

3. That for a given mix, there is a practical limit to the quantity of material passing each size sieve, where a given strength of concrete is required.

4. That an exceptionally high tensile strength of sand in 1:3 mortar is not necessarily associated with a high compression strength of the same material when mixed with the average coarse aggregate in concrete, hence the tensile strength is not a proper gauge of the quality of a sand for concrete.

Justification of the relation between the grading and strength of sands as shown by the curves is dependent upon a combination of coordination of several well known factors or theories of concrete. The maximum strength curve is, doubtless, associated with maximum density, or minimum voids, in the combined aggregates. The decline in strength as the grading becomes finer is associated with increased surface area, and a corresponding increase of voids. As the grading of the sands becomes coarser than that shown by the maximum strength curve, the probability of increased strength indicated by the surface area theory is overcome by a tendency of the coarser grains of sand to wedge themselves in between the coarse aggregate, thus increasing the voids to such an extent that a deficiency of mortar is produced. Hence, a decline in compression strength is recorded with the increase in coarseness of the sand. This, at least, is one

explanation which comes to mind. Probably there are others. The relation of the grading curves to the tensile strength developed in strength indicated by the surface-area theory that is, that the finer the sand the greater will be the surface area to be covered by a unit volume of cement, hence, the weaker the bond.

Utility of the Graph.—By plotting the sieve analysis of a sand upon the graph, a ready means of visualizing the quality of the material for concrete is produced. The area between the upper and lower curves on the graph forms a practical safety zone for the grading of acceptable sands. If the plotted grading of a sand falls outside of this area, in whole or in part, there is but little chance that it will pass standard specification requirements without increasing the proportion of cement.

In making a materials survey for a project, selection of the best source of supply will be greatly facilitated by a comparison of the mechanical analyses of the samples when plotted on the graph. As a precaution in making selection of a sand, it should be realized that several other factors in addition to the grading affect the strength of sands. Variation in structure and soundness, and the presence of organic matter, silt, clay, acids, alkali, and other foreign substances all have their influence on the strength of the sand in concrete. Hence, a considerable variation in strength from the average strength curve for each group shown on the graph should be expected. Eliminating these factors the range of grading for any given strength and mix should be small. Final selection, of course, should always be determined by a more complete laboratory test. But once a complete laboratory determination for the quality of a sand has been made, and the mechanical analysis plotted, any change in quality due to variation in grading is easily detected by a screen analysis made in the field during the progress of construction and plotted on the graph.

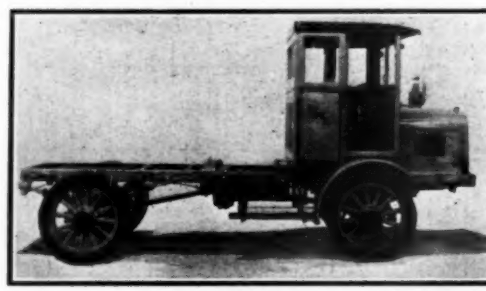
Tourist Traffic Survey in Wyoming

Some interesting figures on tourist traffic in Wyoming were obtained by the State Highway Commission from a survey conducted from July 1 to July 14. The survey was made by means of government post cards containing a questionnaire handed out during the above period by garages, filling stations, camp grounds, etc., to drivers of foreign cars. During this period of 14 days approximately 6800 cards were handed out and up to the date of completing the tabulations a total of 1520 cards had been received. Of this number 109 were disregarded for lack of proper information, and the averages secured are based on 1411 cards, all of which were properly filled out. The data compiled from these 1411 cards show the following:

Average days in state (per capita)	6.38
Average number of persons per car	3.22
Average daily mileage per car	99.50
Average amount of money spent per car per day	$11.21
Average amount of money spent per person per day	$ 3.48
Total mileage traveled by 1411 cars during 14-day period	895,497

New 1½-2 Ton Truck

The Four Wheel Drive Auto Co., Clintonville, Wis., has just placed on the market a 1½ 2-ton four-wheel driven truck, to be known as the Model H. This is not a replacement of an older model, but is an addition to the company's present line. It is being placed on the market after more than a year's development, the truck having been thoroughly tested in South America under severe operating conditions, as well as in the United States. The Model H is constructed along the same general lines as the company's standard Model B, but has the motor in front of the dash instead of under the seat.



Model H Truck

The Model H is rated as a 1½ 2-ton truck. The overall length is 202 in., the body space back of the seat measures 9 ft., 10 in. The weight of the chassis is 5300 lb. The turning radius is 22 ft. 6 in., the wheelbase is 121 in.; the tread is 60 in. The speed per hour is 22 miles on 36x5 solid tires. The motor is of the 4-cylinder 4-cycle Wisconsin Model SU. The valves are overhead and the cylinders are cast enbloc. The bore is 4 in., the stroke 5. The horsepower, SAE rating, is 25.6. The peak horsepower at 2,000 revolutions per minute is 50. This motor has three main bearings. The motor head is removable, all working parts are enclosed, yet easily accessible and adjusted. The steering gear is on the left hand side with the control in the center. There are four speeds forward and one reverse. The construction otherwise, is generally like the standard Model B, full floating axles, front and rear; big service brake and emergency brake, and painted in battleship gray color, trimmed in black.

Building Curbs Without Face Forms

An exceptionally simple and efficient method of constructing integral curb developed the past season by contractors in the Chicago district is described in the September Concrete Highway Magazine. In the smaller communities in this area a low, flat curb has recently become popular. A typical curb of this sort would have a 2-in. flat top, a base width of 10 or 12 in. and a height of 4 or 5 in., leaving the face with so little batter that no face form is needed.

The face is usually given a reverse curve which meets the flat curb top at one end and the pavement crown at the other. This face is secured with a straightedge which rests on strap iron guides.

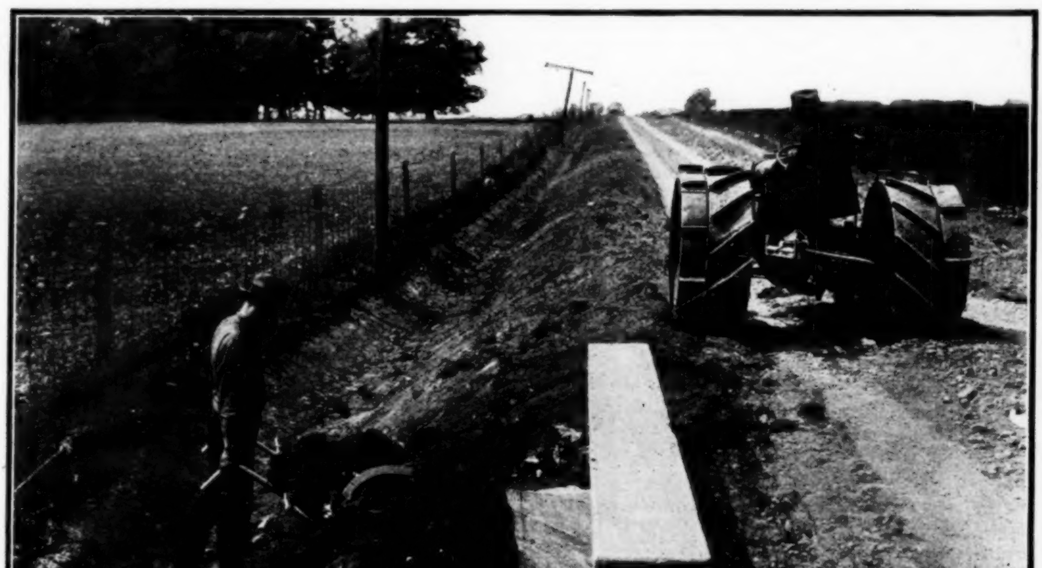
The back forms are set to the height of the curb. The top of the back form is slotted at 10-ft. intervals. Into these slots is hooked one end of a piece of strap iron which has been bent to the shape of the face of the curb. The other end of the strap iron is driven into the ground to hold it rigid.

Except in the area which the curb will occupy, the pavement is struck off with a hand template which rests on the side forms. Enough concrete to make the curb is deposited against the forms by the mixer or by the concrete spreaders where it is left by the strike-off template. This concrete is then struck off with a straightedge whose ends rest on the strap iron guides and the strap irons taken out. The curb is finished with a wooden hand float and brush.

This method requires no face forms and the concrete for the curb does not have to be carried back in wheelbarrows or shovels.

Berm Building with Back Filler

A back filler originally designed for use in shallow trench and pipe line back filling work, is being used with good results in Ohio, in connection with the Fordson tractor in building the berms of roads. The illustration shows a job of this kind. The back filler is made by the Miami Trailer-Scraper Co., Troy, O. In order to use it with the Miami power winch, the company made an extension which consists of three braces, two of which connect to the housing of the tractor on the left hand side, the third one connects to the right hand rear corner of the power winch which is mounted on the right side of the tractor. At the outer end of these three braces there is a sheave wheel and cable guide through which the cable operates. This extension is so designed that the back filler may be operated from either side or from the back of the tractor without turning the tractor around. The extension allows a working latitude of 30 ft. from either side or from behind the tractor.



Building Road Berm With a Back Filler

When Lightning Strikes a Road

Effect on Reinforced Concrete Pavement Described in September Proceedings American Society of Civil Engineers

By WINSTON E. WHEAT
Chief Engineer, Department of Roads and Bridges, Escambia County, Pensacola, Fla.

The varied results of the action of the elements on rigid pavements has recently been the subject of much scientific investigation. Changes in temperature, frost action, and differences in moisture conditions create problems of real significance to the engineer engaged in the design of pavements, the importance of which can hardly be over-estimated.

The writer has recently had occasion to investigate the effect of another of Nature's forces—its most spectacular if not its most powerful—in contact with a reinforced concrete pavement. On the evening of Oct. 12, 1925, during a thunder-storm in the vicinity of Pensacola, Fla., an 18-ft. reinforced concrete pavement on the "Gulf Beach Highway" was struck by a bolt of lightning. The result was one quite contrary to that expected and only a careful investigation proved that the damage done to the pavement was the effect of the action of that element. This inspection was checked by B. D. Howe, Assistant Engineer, Louisville & Nashville R. R. Co.

At first thought, it would seem that lightning, striking a concrete pavement laid directly on a plain of sub-grade, would choose the shortest way to the earth, going directly through the slab. Instead, in this case, it traveled the pavement for a distance of 1,560 ft., about 780 ft. in each direction.

No damage to the pavement is evident except at the expansion joints, at 30-ft. intervals, where a gap of about 4½ in. between the ends of the longitudinal wires of the steel mesh reinforcement, evidently formed an arc, suddenly generating heat sufficient to break out a small piece of concrete and scattering the aggregate for a considerable distance. Where the wires were bared, the galvanization was found to have been burned off. In all cases, the ⅝-in. asphalt expansion joint was melted away at the point of break, evidently having literally "gone up in smoke."

At each joint over the affected area only a small piece of concrete was broken out, or cracked, usually in a triangular shape at a corner of the slab, the piece being about 1 sq. ft. in area and extending slightly below the level of the reinforcement which was 2 in. below the surface. An interesting feature of the action of the lightning was that pieces of concrete broke out in nearly all cases on alternate sides of the road, as if it had traveled diagonally across the reinforcing mesh in each slab. In two cases the fracture occurred in the center of the road, and in one of these a cup-shaped piece was broken out about 4 ft. back of the expansion joint. Another noticeable peculiarity was that in most instances the concrete was broken on one side of the joint, only—the eastern side. This may be explained by the fact that the road was constructed from east to west. In laying the mesh, which came in sections, the ends were placed a varying distance back from the expansion joints, the exact amount depending on the overlapping of the sheets of reinforcement in the slab.

The pavement is of a 5½-7½-5½-in. cross-section, 18 ft. wide, of 3,000 lb. concrete. The aggregates were washed river sand and gravel. In the breaks the coarse aggregate was fractured, as a rule, rather than the mortar.

The reinforcement consisted of a standard steel wire mesh, weighing 44 lb. per 100 sq. ft., and of ¾-in. round steel bars, placed parallel to and 4 in. back of the expansion joints.

The explanation of the effects of the lightning, as reached by Mr. Howe and the writer, may be outlined as follows: This pavement is laid on a pure, white, beach sand of indefinite depth. An unusually dry period had greatly lowered the ground-water level. Moisture is essential to "grounding" lightning. Having struck the pavement the current ran down the steel wire to the end of the mesh near the expansion joint. There the line of least resistance was taken, which was across the width of the pavement, following to its end the steel bar located at that point. Then followed the arc to the steel located across the joint, as this afforded less resistance than to pass through the concrete to the sub-grade and thence through 20 ft., or more, of dry sand to where moisture conditions would permit a "grounding."

The slight damage done was easily repaired by filling the cavities with gravel and bituminous mixture. No other part of the road, which is 12¾ miles in length, has shown any breaks during the two years it has been open to traffic, and the reinforcement has effectually prevented serious cracking of the slabs.

Bascule Span Paved with Concrete.—The 213 ft. bascule span of the new Burnside Bridge over the Willamette River at Portland, Ore., is paved with concrete. This is believed to be the first departure from former methods of paving a lift span.

Use of Lime in Earth Roads

Action on Road Soils Outlined in Paper at 1926 Meeting of National Line Association

By H. W. WOOD, JR.
Highway Department, National Lime Association, Washington, D. C.

The investigation of the action of lime on road soils was started about 2½ years ago by the National Lime Association cooperating with the University of Missouri and by the U. S. Bureau of Public Roads cooperating with several state highway departments. This investigation has consisted of laboratory work, together with actual field tests, and while the experiments are not yet completed, several things have been discovered which might be of interest here.

How Lime Treatment Is Made.—In making the lime treatment hydrated lime is thoroughly mixed into the road soil to a depth of 6 in. by plowing and discing. To obtain the best results the road should be quite dry when the treatment is made, in order to get an intimate mixture. The road is then dragged to the proper cross section and opened to traffic which quickly packs it.

Lime treatment greatly stabilizes heavy clay and silt soils. Those soils immediately lose their stickiness and extreme plasticity, becoming granular in structure, which renders them capable of sustaining normal traffic loads without failure when wet.

Up to this point we have been well satisfied with the success of the lime treatment, but lacked a practical test to guide us in making recommendations.

Test for Soil Stability.—In order to determine this stabilizing effect accurately a series of investigations was conducted at Ohio State University under the supervision of Professor Eno to devise a test for measuring the stability of soils in the laboratory. The soil to be tested is placed in a steel cylinder 3 in. in diameter and is forced through a 1½-in. hole in the bottom by means of a plunger, the load being applied in a universal testing machine.

When the soil holds a definite percentage of water, the load required to force the soil through the hole is a measure of its stability, or its resistance to deformation under load.

On several clay soils tested by this method a lime treated soil holding 30 per cent of water showed twice the stability of the untreated soil holding only 25 per cent of water. In view of the fact that most clay soils fail under traffic when holding about 25 per cent of water, an increase in their stability in this range of wetness may often prevent a failure of the road. It will be seen that there the untreated soil with 25 per cent of water would fail under traffic, while the lime treated soil containing 5 per cent more water would remain smooth and unrutted. That is exactly what we found in the actual field tests.

Uses for Lime Treatment.—There are several practical uses for lime treatment of soils. On the back road in the country, where the traffic is not heavy, and where a hard surface road would be too expensive, it seems advisable to treat the troublesome clay sections with lime. By thus keeping these sections hard and firm at all times, many miles of road will be kept open to traffic in rainy weather and after the spring break-up.

Where the traffic is heavy enough to warrant a better road, the subgrade may be treated with lime and the surface covered with a thin layer of crushed stone or gravel. Without the lime this thin layer of surfacing material would soon sink into the clay and disappear; but with the increase in stability and loss of plasticity due to the effect of the lime, the thin layer of gravel or crushed stone will remain on top. This will result in a saving of 5 or 6 in. of gravel or stone.

It is often a great help to use lime around a construction job or on a farm to dry up mud holes or to prevent them from forming. Hydrated lime can be strung along the tracks and the trucks will work it in.

Maintenance of a lime-treated road is simplified in several ways. (1) The soil loses its stickiness and is not picked up by the wheels of vehicles, to fall on the road and form clods. This keeps the road from becoming rough. (2) The increased stability of the soil prevents the wheels of vehicles from cutting ruts after the surface begins to dry. (3) The lime-treated road dries out faster and can be dragged many hours sooner than the road without lime. (4) The treated soil mulches more easily under the drag, making it easier to obtain a smooth riding surface.

Another possible use of the lime treatment is in connection with aviation landing fields. When a new field is established there is generally some grading to be done and this leaves the clay exposed. It is believed that a shallow lime treatment will eliminate the stickiness of the soil in these spots, allowing it to remain in place, undisturbed, when planes taxi over it, thus facilitating the growth of grass. The lime will also act as a fertilizer in promoting the formation of sod.

Test Roads.—Test roads are being built in Wisconsin using a thin gravel surface over the lime-treated subgrade. This work will be done by the Maintenance Section of the Wisconsin State Highway Department.

The University of Illinois is building several

test sections near Champaign this summer to determine the value of lime treatment preparatory to oiling earth roads. It is expected that the lime will stabilize the soil, and at the same time prevent the emulsifying of the oil by the clay. Both of these should lengthen the life of the oiled surface.

In Missouri and Virginia sections are being treated with lime to obtain further information concerning its use on earth roads without the addition of any surfacing material. In Ohio another short section of subgrade for concrete pavement has just been completed, and the tests in the laboratories at Ohio State University are progressing. With the results of all these tests compiled, together with the results already obtained in previous tests, definite recommendations for lime treatment of earth roads, subgrades and landing fields can be made.

This project has now been brought out of the experimental stage, for the new test will enable us to recommend the amount of lime required on any soil. With some knowledge of local conditions as to grade, location and drainage, we can tell how deep the treatment should be.

The "Original" Contract Plan

Practical Suggestion for Its Identification Given in Journal Boston Society of Civil Engineers

By STURGIS H. THORNDIKE
Of Fay, Spofford & Thorndike, Consulting Engineers, Boston, Mass.

A plan today often passes through at least three stages—plot on drawing paper, tracing, and blueprints.

A construction contract customarily refers to "the plans." Among all the reproductions and duplications of any given plan, *which* is referred to? Which sheet of paper or cloth is "the original" plan?

Note that "original" may be used with two quite distinct meanings. It may mean the first stage in which a document appeared in complete and final form; in this sense, the lead type, or even the typewritten printer's copy, might be considered the original of a whole edition of printed specifications. On the other hand, it may mean the particular document, perhaps one of many similar reproductions, which is identified as the primary standard, and is the origin of authority in cases of doubt. The latter meaning must be the one intended in any signed agreement, such as a contract. It is unfortunate that "original" has these two meanings, but there seems to be no other word in the English language which, on the whole, expresses as well all the desirable connotations of meaning No. 2.

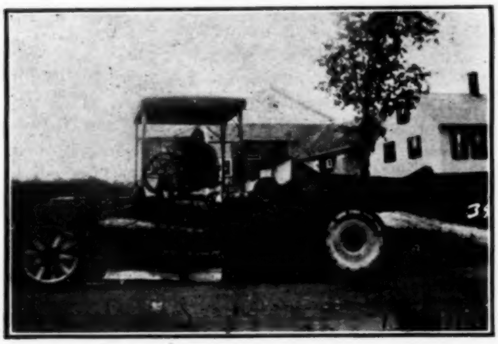
Methods have developed and needs have changed till today the tracing is not very well adapted to be used as such an "original plan." It is frequently the property of the engineer, not of either of the contracting parties. It is needed for constant use; it can hardly be spared to be "attached to" or to permanently "accompany" the other contract documents, or even to be so filed that it will be safe from loss or damage. It is the most convenient sheet on which to record revisions, including the final "revision as constructed"; even if made extremely intelligently such revisions make it difficult to be sure just what was on the tracing at the time the contract was signed with its reference to this tracing as one of "the plans."

A modern blueprint, on the other hand, makes an admirable "original contract plan." It is durable, permanent. It is as truly a "plan" as is the tracing or the drawing paper stage. It enables a contract to be executed in duplicate, triplicate, etc., with no question that the copy delivered to the owner differs in any way from the copy delivered to the contractor. It is singularly difficult to forge, any alterations being at once obvious. It can actually be "attached to" or permanently "accompany" the other contract documents. Meanwhile the tracing is available for all the current and customary needs.

As a practical suggestion: After the tracings are in final contract form, letter "Original Contract Plan" in coarse black pencil diagonally across the title of each; strike off the number of sets needed in executing the contract; and erace the pencil lettering. The pencil lettering will print on each of these blueprints as a "ghost" marking, differentiating these prints from all others, and difficult to forge exactly on any print taken later. In the agreement, in the identification of the contract drawings, state that they are blueprints, X drawings in a set, and that an official set, in which each print is marked "Original Contract Plan," has been received by each of the parties to the agreement. It is not very expensive for each party to file such a set for verification reference only, other sets of prints being provided for current use in the office or on the job. Each party then has complete and exact record of what was on the "plans" at the time he signed the contract. If the engineer acts as clerk of the contract, and he also has a signed copy of all documents and a set of "Original Contract Plans," the probability is further increased that an unquestioned original document can be produced in case of need.

Dump Body on Grader

The State of Maine has made an addition to the equipment of its Maintenance Department Hadfield-Penfield "One Man" grader by the addition of a dump body which is carried over the tractor and is of sufficient capacity to carry stone for patching or repair purposes. In this way the road is not only scraped and graded but any small amount of extra stone that may be needed can be supplied without additional equipment in the way of trucks. This dump body is easily



Grader Equipped With Dump Body

dumped to the rear or only a small amount of material can be supplied if needed. The equipment is particularly advantageous in patching small holes no matter of what material the patch is made. The use of the dump body saves the cost of operating a truck which might be necessary to carry even a small amount of material.

Income Tax and Public Works Contracts

The Washington office of the Associated General Contractors has issued in one of its News Letters the following information concerning deductions on income tax:

"Where warrants issued by a city, town or other political subdivision of a state are accepted by the contractor in payment for public work, the question immediately arises as to the method of entering such warrants in the books of account and the method of computing the profit on the contract.

"Article 37 of Regulations 65 provides:

"'The profit of an independent contractor from a contract with a state or political subdivision thereof must be included in gross income. Where warrants are issued by a city, town or other political subdivision of a state, and are accepted by the contractor in payment for public work done, the fair market value of such warrants should be returned as income. If for any reason the contractor upon conversion of the warrants into cash does not receive and cannot recover the full value of the warrants so returned, he may deduct from gross income for the year in which the warrants are converted into cash any loss sustained, and if he realizes more than the value of the warrants so returned, he should include such amount in his gross income of the year in which realized.'

"A contractor should therefore take up in his books of account only the fair market value of such warrants at the time the warrants are received.

"In computing the profit on such contracts the warrants should not be considered at face value, but at only the fair market value at which such warrants are entered in the books of account.

"For example, a contractor is paid in non-interest bearing city warrants for work done. The contract price of the work is $75,000. The contractor receives non-interest bearing warrants having a face value of $75,000 in payment for the work. However, these warrants, for reasons not necessary to be considered here, had a market value of only $67,500 (the best offer obtained being at 90). This contractor should therefore consider, in determining his profit on this contract, that the proceeds of this contract amounted to only $67,500 rather than $75,000.

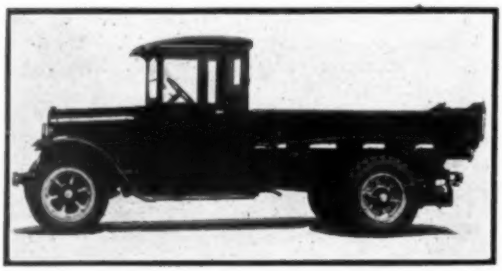
"The proper treatment of this one item operated to reduce this contractor's taxable income for that particular year by $7,500, with a substantial saving in his taxes."

New 2-Ton Truck

The latest additions to the line of commercial cars and trucks being sold by Dodge Brothers dealers are two new types of 2-ton capacity. Like their smaller predecessors the new chassis will be supplied with a variety of bodies suited to practically every requirement. Two lengths only are made: The shorter, for 9-ft. bodies, has a wheel base of 137 in., and the longer, which is for 12-ft., bodies, has a wheel base of 162 in. Both chassis are equipped only with pneumatic tires, with either single or dual rears optional. Where single tires are used 32 x 6 in., size are fitted in front and 34 x 7 in., at the rear. For dual rear tire equipment disc wheels are standard with 34 x 5 in., tires both front and rear.

The pressed steel frame side rails for the shorter chassis are 7 in. deep and for the larger 7⅛ in. Due to the lower bending moments in the short frame its thickness is $\frac{3}{16}$ in. while that of the longer frame is ¼ in. Front springs on both chassis are 37 in.,

long, 2 in., wide and have 9 leaves, while the rear springs are 56 in. long, 3 in. wide and have 11 leaves. The semi-floating rear axles employ a spiral bevel gear final drive with a reduction of 6.286 to 1. Both service and hand brakes are of an internal self aligning type operating in heavy pressed steel drums at the rear hubs. The brakes are so connected that the pedal operates all four bands while the brake lever actuates only



Graham Brothers New 2-Ton Truck

two. This feature, it is declared, insures long life and even wear of the brake facings.

This new and larger truck embodies the same well tried constructional features found in Graham Brothers 1-ton and 1½-ton trucks.

The power unit consists of the well known Dodge Brothers 4 cylinder engine which has given such satisfactory service in Graham Brothers trucks and motor coaches with a heavy duty truck type transmission. The heavier frame, springs and other chassis parts insure service with 2-ton loads just as satisfactory as that supplied by the smaller trucks hauling the loads for which they were designed.

Driven Well Important Factor in Building Highway

An interesting development during the course of investigation by the California Highway Commission for the highway through Imperial County sand hills, was the boring of a well in Open Valley, a small tract on the route of the highway almost in the center of the Sand Hills, which for some unexplainable reason has not been inundated by the advancing sands. There was no water supply for many miles. Water requirements would greatly increase the cost of the work, regardless of the type of pavement finally decided upon. Some scoffed when the commission began drilling in the middle of the desert, but to the surprise of everyone a flow of 500 gal. of water per minute was struck at a depth of 92 ft. Drilling was continued to a depth of 153 ft. This well put down by the commission at a cost of $1,350 solved the water question and saved the state many dollars in connection with the Sand Hills project. It was a factor of utmost importance in the construction of the highway, one of the most spectacular paving projects in America.

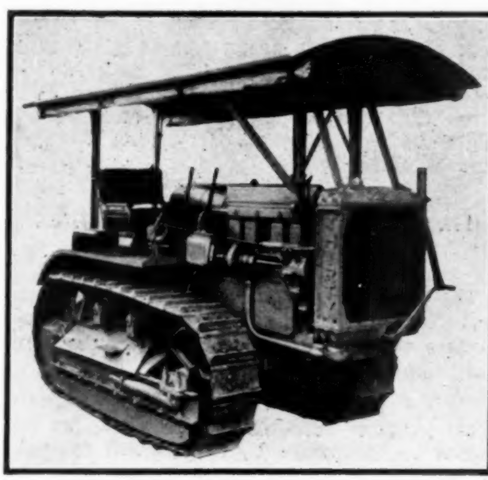
Tractor Has High Driver's Seat

Further advance in the utility of the "Caterpillar" Thirty tractor is evidenced in an announcement made recently by the Caterpillar Tractor Co. that the new model "Thirty" with a high driver's seat, is now in production at the San Leandro, Calif., plant of the tractor manufacturing company.

Greater operative visability and increased driving ease are claimed for the new design by engineers who have given the new model every possible test, and a ready welcome is expected for it in the many spheres which are finding the "Caterpillar" to their advantage.

It is specifically stated by the Caterpillar Tractor Co., however, that the lower-seated model will still be produced, owing to the demands of orchardists and others for more clearance where overhead obstacles require plenty of head-room for the operator.

The announcement of the high-seat "Thirty" follows another announcement made recently by the "Caterpillar" factory in which a promise



New Model "Caterpillar" Thirty Tractor

of lower prices, made when the Best and Holt companies were united, was fulfilled. The new scale cuts the price of the "Sixty" from $5,500 to $5,000, F. O. B. either San Leandro or Peoria; that for the 5-Ton from $3,650 to $3,250, F. O. B. Peoria; that for the "Thirty" from $3,400 to $3,000, F. O. B. San Leandro; and that for the 2-Ton from $1,950 to $1,850, F. O. B. Peoria.

The Care of Road Equipment

An Article in the September Highway Builder

By LION GARDINER
Vice President, The Lakewood Engineering Co., Cleveland, O.

About 18 years ago I was getting my first construction experience on a hydraulic dredging job. I remember the satisfaction there was when from a distance I could pick out the three different exhaust pipes and note the steam coming from each one of the three. I know this was a sign that there were 150 yd. of material being put in place each hour, and that the outfit was making money.

So it is with road building. If from the job office you can see the empty trucks coming in, you know the job is moving along. Or, if from a distance you can see the skip going up and down regularly, you know that you are getting your yardage. It is a mighty satisfactory feeling—that one of a smoothly running job. No fussing, or rushing around, just something for everyone to do, and everyone doing his job.

We may divide the operating organization on the job, into two parts: The human, and the mechanical. Both are equally important to low production costs. The most expensive machine cannot turn out good work in the hands of incompetent operators who have neither pride in their work nor understand just what part they are to play. No more can a good superintendent get good production and low costs unless his equipment is in first-class shape, and has the care to which it is entitled.

This mechanical organization (by which I mean the various machines on the job) is entitled to the same care, thought and study as the human organization, for without the former in good shape, the latter cannot get continuous production.

On the mechanical side of the job organization, the manufacturer and the constructor are to an extent co-partners. Reliable manufacturers spend thousands of dollars in experiments and research work, testing new materials, working out new ideas, all toward the improvement of reliability, life and operating results. They know their success in business depends upon the service the machine renders. Providing the manufacturer has turned out a good tool, to an extent his reputation is in the hands of his customers, for if it is not maintained in good mechanical condition, it cannot produce for its owner, and its failure reflects on the manufacturer's reputation. Do your share in maintaining its condition and gain not for yourself alone but for the men who are putting thought and money into making better tools for you.

It is a 50-50 responsibility, and not like the story of the mother who said, "Jack, are you letting Willie have your sled part of the time?" and Jack's response, "I do, I have it going down hill, and he has it coming up!"

"If You Need a Tool You Pay for It."—There is an old saying which has 100 per cent truth in it, namely: "If you need a tool, you pay for it whether you buy it or not." The thinking constructor realizes this and goes the limit in putting the best equipment he can procure on his job, but he must go further to reap the full benefit—the must organize to take care of it—to make his men have pride in its condition and its output.

When an important machine on a job, a 21-E paver for example, is down for an hour, the loss is far more than just the pay roll for the short time delayed. It is hard to figure just what it will cost the constructor in dollars, but we can be pretty sure that his estiamte for the week's work will be cut down $250 and more, for every hour that the job is delayed.

We insure against fire losses—we insure against accidents—we protect many of our interests through payments of insurance premiums—but who is there who will issue a policy covering losses due to breakdowns?

We must find another solution to prevent these losses, and a large percentage of them can be saved through better care of equipment. It is true we must pay a premium, but it will be returned many times over. Perhaps it is a nickel or more on the hourly rate to get a better man as an operator, or perhaps it is the cost of a good master mechanic, whose sole job is to inspect and keep in repair the equipment.

The highest grade man as operator, one who has pride in his work, will not only get more and better work out of his machine, but he will add a year or more of useful life to it.

Why is it that some paving tools are going good after 70 to 80 miles of road are finished, and others are ready for replacement at the end of the second season? The answer lies in the operator, and the man who is responsible for its upkeep. This upkeep does not merely mean some oil splashed around the machine a couple of times a day—it means a careful oiling and greasing—it means thorough cleaning at night, tightening of the bolts here and there, and a willingness to make minor adjustments before they become major repairs. It means the keeping on hand of certain spare parts which are most likely to go wrong, so as not to have to wait for factory shipment. The interest on the investment in such parts is a small premium to pay for the

value of the time saved by having them available.

Production Not an Accident.—As I said before, it is a happy feeling when the skip is going up and down with regularity, day in and day out, but it is not just an accident. The mechanical organization is functioning properly, the equipment is being given its share of thought and planning, and the slight added expense to the job, will prove to be a mighty small premium to pay for the protection to the job profits. Such equipment has not only been watched carefully during the working season, but no doubt the yearly men have given the equipment a thorough overhauling and inspection during the winter months. It is this sort of care and planning which adds to the profits of the coming year.

I recall a Road Show at which a constructor called me to one side and gave me a pretty stiff calling down because of the amount of his repair bill the preceding season. I told him at the time that I could not accept responsibility for the situation, because the amount of his repairs per unit was approximately four times the average repair expense which our records showed was to be expected. Upon my return to Cleveland I looked up the orders, and found his claim as to quantity of the purchases was accurate, and wrote him a letter suggesting that he look within the organization in an attempt to remedy the difficulty, but at the same time, enclosing a credit memo for a portion of the amount, because it was so much higher than it should have been.

A Merit Prize Plan.—Last summer, during one of my inspection trips covering jobs in different parts of the country, I visited his work. My first request at the job office was to be shown the record of repair parts ordered up to date, which was the latter part of August, and learned that the value of the repairs purchased had been reduced 90 per cent. While the records were being looked up, I had been very much interested in reading a notice posted on the bulletin board.

I wrote to this constructor and asked him how the plan had worked during the season, and his answer to me was as follows:

In reply to your letter of January 16th asking for information as to how we cared for and maintained our equipment the past season:

As you said in your letter, we offered a prize of $5 each pay day and I am inclosing a copy of the bulletin in regard to this. I wish to say here it worked wonders.

The first two weeks our machinery looked as if it had been overhauled and it was kept looking practically new the rest of the season. This bulletin was issued June 1st. I will give you one illustration: We had an Erie steam crane that had not been cleaned and greased good for two years. After this bulletin came out the operator and the fireman certainly made this crane look like new and won the first prize. You can see that we had five different men on as judges so that there can be no partiality shown. This has been the most effective method we have found to keep the machinery in shape. Cleaning and oiling is the life of the machinery. We have found that when we are able to get the men to keep the machines cleaned and oiled, need for repairs is eliminated to practically the last degree. This season caused the men to become very much interested and the result was wonderful.

The foregoing speaks for itself; and if the constructor reduced repair bills to the other companies in the proportion that he reduced his payment to us, that saving in dollars was probably a small item alongside of his increased profits because the operating delays had been reduced in similar proportion, and greater yardage laid within the same length of time.

He had formed his own insurance company to protect himself against losses, and had looked within his organization to find the protection, which he could not find outside. The premium which he paid was returned to him many times over during the season.

Governor's Day at Chicago Road Show

More than 70 active and former governors will be asked to participate in a governors' day program to be held in Chicago on Tuesday, Jan. 11th, in connection with the 24th annual Convention and Road Show of the American Road Builders Association.

H. G. Shirley, President of the American Road Builders' Association and Chairman of the Virginia State Highway Commission, who is completing arrangements for the big highway meeting scheduled for Good Roads Week, Jan. 10th to 15th, has announced that all former governors will be invited to attend the meeting in addition to those now in office.

"Special problems of interest to state executives in the construction and maintenance of their state highway systems will be discussed by speakers of international importance on Governors' Day," Mr. Shirley said. "The delegates will be welcomed by Governor Len Small of Illinois, according to present plans.

"Arrangements for the entertainment of the chief state executives will include a banquet in their honor to be given by the officials of the American Road Builders' Association. The banquet will follow a tour of the $3,000,000 road machinery and materials exhibit to be held in the Chicago Coliseum and adjoining buildings."

President Shirley announced the appointment of H. K. Bishop, Chief of the Division of Construction of the United States Bureau of Public Roads and a member of the Association's Board of Directors, as general chairman of the program committee. Paul M. Tebbs, of the Pennsylvania Department of Highways, and S. M. Williams, Chicago, a member of the Board of Directors, were appointed sub-chairmen.

Patching Pavement Cuts

An unusual combination of force account and contract work has been adopted in Albuquerque, N. Mex., for filling pavement cuts for utilities. We are indebted to the California Constructor for the following details:

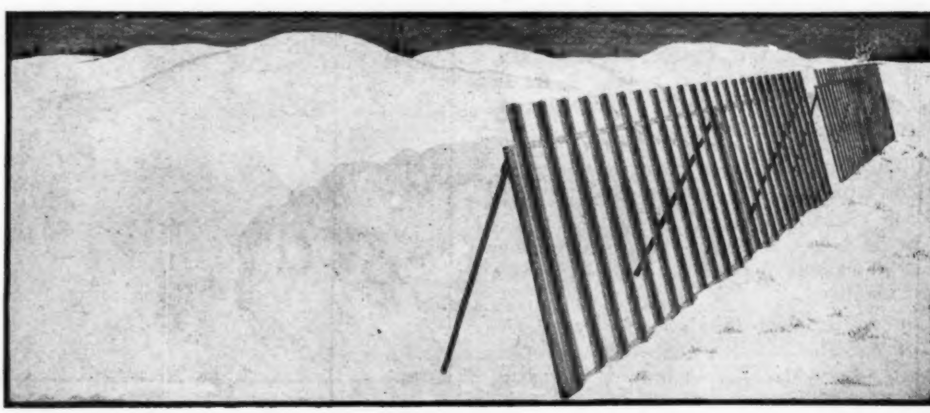
Briefly, the city forces fill the cuts as they are made temporarily with concrete laid as base and surfacing, or in two layers, then when a hundred or so cuts have accumulated a contract is let for removing the concrete top layer and substituting bitulithic to correspond with the rest of the pavement. As explained by City Engineer Frank Kimball, the city of Aubuquerque has only two types of paving, black base 3 in., and concrete 5 in., each with a 2-in. Warrenite bitulithic surface. Warren Brothers have a local representative in the New Mexico Construction Co., and to date this company has done most of the paving in the city.

The usual paving "year" is from four to six months and it has been found that during the remainder of the year approximately a constant number of paving cuts have been made. The procedure followed for a long period of time was to have the local representatives of Warren Brothers patch all cuts in the city about once each month. However, it was found to be a costly method if there was no paving being laid at that time, as it meant firing up the asphalt plant and calling in skilled labor to do this work. After paying out considerable money for this sort of work, it was decided to have the city forces do all patch work, using concrete, and then after the accumulation of a hundred or more such patches to have the Warrenite surface placed on them under one order.

It was found, when the surfacing crew chipped out the top 2 in. of concrete preparatory to placing the patch, that it required considerable labor, so in order to cut down the expense and to speed up the work another method was resorted to. After the paving cut had been prepared to receive the concrete by the city forces, by excavating 6 in. below the base of the paving and 6 to 12 in. underneath the paving surrounding the cut, the concrete patch was placed in this opening and brought to a point within ½ in. from the top of the base or foundation. A layer of dirt or adobe about ½ in. thick was then placed on top of the wet patch and then more concrete placed on top of the adobe to bring it flush with the surface of the finished pavement. It was found by doing the work this way that the top layer of concrete was very easy broken out by the surfacing crew, and that these patches held up satisfactorily under traffic, between surfacing operations.

Metal Units to Control Drifting Snow

Development of a new system of portable metal units to prevent snow drifting on highways and railways is announced by the Metalvane Snow Control Corporation of Sioux Falls, S. Dak.



Installation of Metal Unit Snow Fence

Knowledge of air current action is applied in the design of the metal snow barrier, the principle of which is a number of V-shaped vanes of metal 3 in. wide with 3 in. spaces. The wind strikes the faces of the vanes, is deflected across the openings where it slows the wind velocity but does not stop it directly behind the unit.

As a result the snow is stated to clear the units and drift just behind them. The action is positive and automatic in its regulation. The units are stated to be self-cleaning,

do not clog with snow and the resulting drifts form the same characteristic formation.

The new snow barrier has been tested by public highway organizations in the Northwest and has been proved practical. The portable feature has been of special advantage to the patrolman who travels in a light truck over his division, keeping the roads open during a storm. Sections of the metal barrier are carried in the truck and placed wherever necessary according to prevailing wnids, to protect cuts and other points subject to drift.

The Metalvane frames are made of 1 in. x 1 in. x ⅛ in. angles, 12 ft long and 4 ft. high. Vanes are made of galvanized metal, their V-shape giving them ample strength to resist bending while handling. A unit folds to less than 3 in. in thickness for storage. A wrench and hammer are the only tools necessary for erection or knocking down. A unit weighs 70 lbs.

Prize Contest for Super-Highway Design

In order to bring out the most practical and original plan for the construction of super-highways in the metropolitan area of Chicago, the Metropolitan Super-Highway Association, 503 Burnham Bldg., Chicago, is sponsoring a prize contest for the best ideas with reference to the construction beauty, economy and efficiency of a road 200 ft. in width. The contest closes at 5 p.m. Dec. 1. The conditions are as follows:

1. All drawings shall be clear, concise, and in ink, or capable of reproduction.
2. Each entrant may submit as many exhibits as he deems necessary to properly show his ideas, and must have cross-section of each design submitted.
3. Confine problem to right-of-way of the width of 200 ft.
4. Particular attention should be paid to the following elements:
   a. Safety.
   b. Practicability.
   c. Economic construction.
   d. Separated grades for highway and railroad crossings.
   e. Rail transportation may or may not be provided for.
   f. Beauty of design.
   g. Provide for all public utilities, such as gas, water, sewer, drain, lighting system, etc.
   h. Adequate provision for fast and slow moving traffic.
   i. A scheme of gradual development from the present condition which is mostly farm property to a thickly settled condition with business.

The first prize will be $1000 in cash; the second, $300 in cash; and the third, $200 in cash. The judges of the contest are:

D. H. Burnham, President Chicago Regional Planning Association.

Hugo E. Young, Engineer Chicago Planning Commission.

Maj. R. F. Kelker, Consulting Engineer.

Geo. A. Quinlan, Superintendent of Highways of Cook County.

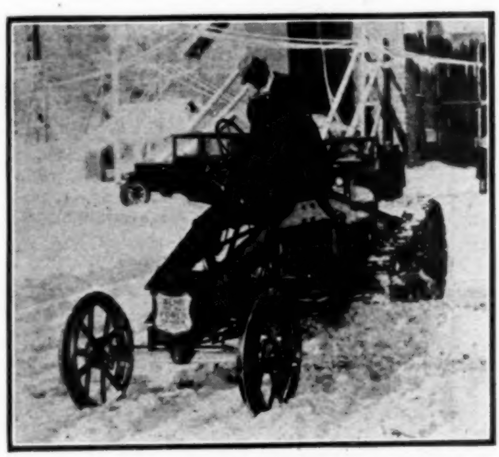
Claude Hanson, Superintendent of Highways of Kane County.

E. L. Gates, Superintendent of Highways of DuPage County.

G. N. Lamb, State District Engineer.

Removing Ice With a Grader

A Wehr grader equipped with the Trackson Full Crawler was used very successfully by the Queen Victoria Parks Commission, Niagara Falls, Ont., in removing ice from the roadway of a boulevard along the banks of the Niagara River. The ice was formed by the freezing of spray from Niagara Falls. Ice 12 in. thick on a roadway 36 ft. wide and 1500 ft. long was broken up in one hour and removed in less than two hours.



Clearing Roadway Through Victoria Park of the Ice After It Was Broken by the Scarifier

For breaking the ice a 9-tooth blade scarifier was used on the grader. After breaking the ice it was cleared away by using the grader equipped with a 12-ft. blade. The unit also is used on patrol work and snow removal on the 18-mile boulevard between Niagara Falls, Ont., and Bridgebury, Ont.

The 1927 Road Builders Convention and Road Show

It is expected that the 1927 Convention and Road Show of the American Road Builders' Association, which will be held in Chicago during Good Roads Week, Jan. 10-14 inclusive, will eclipse all previous gatherings of the association.

The Road Show will be held in the Coliseum as usual but the Convention and headquarters this year will be at the New Palmer House, where larger rooms are available for the meetings and banquet. Official headquarters will be opened Dec. 10, 1926.

H. G. Shirley, president of the Association and chairman of the Virginia Highway Commission, has arranged a program consisting of two sections—one arranged for engineers and officials and the other for contractors, manufacturers and material producers.

The chairman of the Program Committee is H. K. Bishop of the Bureau of Public Roads and he has assisting him S. M. Williams of the Autocar Co., in charge of the Contractors' Program; and Mr. Paul Tebbs of the Pennsylvania State Highway Department in charge of the Engineers' Program.

The preliminary plans have already been completed and a program is promised that will prove both interesting and valuable in the economic construction, maintenance and operation of highways.

Already the applications for space have exceeded that of last year, when approximately 300 carloads of the latest improved road building machinery and materials were on exhibition.

Many exhibitors have displayed their new improvements at the road show for years but this year the applications show that an exceptionally large amount of new developments and improvements will be shown, a fact most interesting to the engineer, official and contractor.

Many new features will mark the 1927 Convention and Road Show. Tuesday, January 11th, will be designated as "Governors' Day." All State Governors will be invited and many ex-Governors—especially those that have been identified with the "Good Roads Movement."

President Shirley and the Association Directors will entertain the visiting Governors at a good Roads Governors Banquet on the evening of Governors' Day. The chairman of the Governors' Day Committee is Fred Reimer, Consulting Engineer, East Orange, N. J.

January 12th will be "Pan-American Day." All countries in North, Central and South America will be invited to send delegates and to have exhibits. On "Pan-American Day" a portion of the program will be presented by delegates from Pan-American countries, setting forth the road situation in those countries. Last year with no special arrangements being made for Pan-American delegates, seven different countries were represented.

The Pan-American Day Committee will be headed by Col. R. Keith Compton, Director, Department of Public Works, Richmond, Va. One of the features will be a banquet given by the president and directors to the appointed delegates.

Again the Entertainment Committee will be headed by Arch Cronkrite of the Universal Portland Cement Co. Those that have attended the conventions in the past few years know that the few hours between sessions, and in the evenings, have been provided with high class entertainment of a variety that was truly appreciated by road builders.

The Road Builders Banquet has grown into one of the important functions of the convention. Last year it was necessary to limit the number to 1,200, and a number of people were deprived of the pleasure of hearing Chas. Schwab make his excellent address.

This year ample provision has been made for 2,000 road builders. Paul Griffith of the American Tar Products Co., Pittsburgh, Pa., is again to head the Banquet Committee and he and President Shirley are now making arrangements with a nationally known speaker who is sure to interest everyone present.

Reservation booklets showing the name and location of all hotels; and blanks for the purpose of making reservations may be obtained from all exhibitors and will be furnished to all those that registered last year.

The Coliseum Committee will be headed by J. E. Tate of the Portland Cement Association, and his presence will assure the proper handling of all details at the Coliseum.

The Press Committee, which functions throughout the year, is in charge of R. M. Arundel.

Registration this year will be in charge of Wm. Ogden of the Lakewood Engineering Co., Cleveland, O. He will be prepared to handle 35,000 people in the four days of the convention.

Reduced railroad fares will be granted to all members of the American Road Builders' Association and their families. Previously the railroads had granted reduced fares to all delegates but this year it is granted only to members. Detailed methods of securing reduced fares will be furnished all exhibitors and those that registered last year.

The Bureau of Public Roads has planned a novel exhibit, both interesting and educational, for the Coliseum and also for the Palmer House, adjacent to the convention meeting rooms. In this location at the Palmer House

the Association of State Highway Officials, Highway Research Board, several State Highway departments—and some of the Pan-American countries will also have exhibits. Several technical associations will be invited to exhibit at this technical and educational exhibit.

With the advantages of an exposition of the latest improved road building machines and a convention presenting the latest methods, all of which can be attended in four days, it is hoped that the several states, counties and cities will send many delegates in order that they may keep pace with the latest methods which are shown at this, the greatest exposition of its kind in the world.

Detailed or additional information may be had from the Business Director, Chas. M. Upham, Raleigh, N. C.

Industrial Notes

The annual sales meeting of the Ruggles district managers was held at the home office of the Ruggles Motor Truck Co. in Saginaw, Mich., Sept. 8th, 9th and 10th. District managers from all parts of the United States and Canada were on hand to discuss the sales program incident to the presentation of the new complete line of Ruggles motor trucks, which are ready to be announced to the public. Two features of the meeting were addresses by Ex-Congressman Joseph W. Fordney, president of Ruggles Motor Truck Co., and Albert Sleeper, ex-governor of Michigan and a director of the company. It was announced at this meeting that the increase in sales in all territories covered by Ruggles district managers had been very satisfactory, the first half of this year showing a 24 per cent increase over the first half of 1925, with prospects unusually promising for the balance of this year.

The Speeder Machinery Corporation, manufacturers of gasoline shovels, cranes, draglines, Fairfield, Ia., will soon remove its factory and general offices from Fairfield to Cedar Rapids, Ia. The company is building a new modern plant in the latter city, which it expects to occupy so that production in Cedar Rapids will begin Jan. 1, 1927. Until then production will be maintained at the Fairfield plant. The new plant will greatly enlarge the company's facilities. A considerable expansion is contemplated to enable the company to better supply the demand for its products, which has outgrown the present manufacturing plant in Fairfield. The new location will offer a greater labor market, a location in a prosperous industrial city and improved shipping arrangements.

The Link-Belt Co., Chicago, has opened a new branch office in Utica, N. Y., at 107 Foster Bldg., 131 Genesee St. This, their 34th office, and the third within the State of New York, is to be devoted especially to the sale of Link-Belt silent chain and Link-Belt roller chain; and will be in charge of F. P. Hermann, Jr., who has had many years of silent chain experience and contact while located in the New York office of that company.

R. C. Brower has recently been appointed as general manager of the Timken Roller Bearing Service and Sales Co., which maintain 25 direct factory branches and several hundred authorized distributors. Mr. Brower will make his headquarters in Canton, O., at the main plant of the Timken Roller Bearing Co., but will devote a great deal of his time to maintaining contact in the field. He is well known in the bearing industry, having been associated with it since 1913; and for the past four years with the Timken Co., in both the automotive and industrial machinery sales divisions. Prior to that he was for many years eastern and central district manager of the Bearing Service Co., which was absorbed when the Timken Roller Bearing Service and Sales Co. was organized.

Lawrence E. Buzard, general sales manager of the Fate-Root-Heath Company, Plymouth, Ohio., was born at Adario, O., July 1, 1896, and died at Cleveland, O., Sept. 12, 1926, after a brief illness following an operation for appendicitis. He spent his boyhood in Plymouth and graduated from the Plymouth High School, later attending Ohio State University. Mr. Buzard enlisted early in the World War and was promoted to the rank of corporal of Battery B, 136th Field Artillery. He was in engagements at St. Mihiel, Meuse, the Argonne and Defensive Sector in France and received an honorable discharge and medal. In January, 1920, Mr. Buzard accepted a position with the Fate-Root-Heath Co. of Plymouth. Starting at the bottom, by close application, industry and ability, he rapidly advanced from one position to another until at the time of his death he was general sales manager of the company. Mr. Buzard was a member of the Lutheran Church and of Ehret Post No. 447, American Legion. He is survived by his wife, two sons, mother, father, and two brothers.

The Speeder Machinery Corporation, Fairfield, Ia., announces recent appointments of district sales representatives as follows: H. W. Parsons, Pacific Coast District; R. E. Coop, Southwestern District; W. H. Boyd, Southern District; L. A. Bartlett, Eastern District. The company also opened a sales and service office at 90 West St., New York City, in charge of D. W. Lehti, who will have charge of Eastern New York and New England territory.

The Chicago Pneumatic Tool Co. on Oct. 1 opened its new building located in the central manufacturing district on Iron St. near 37th St., Chicago. This building is the new home of the Chicago sales and service branch and has been constructed for the benefit of the many customers who will now be able to receive even better service, with the new facilities of this building. In order to assure customers of prompt deliveries this structure has been erected with a loading platform on the east side to accommodate the loading of two freight cars on the Chicago Junction Railway. It also has loading doors for trucks, and, in short, is designed with all necessary facilities to insure immediate service.

Paul B. Hess, manager and secretary-treasurer of the New Holland Machine Co., New Holland, Pa., died recently. He was born at Brownstown, Pa. He received his early education in the Brownstown public schools. In the year 1905 he graduated from the Pennsylvania Business College, at Lancaster, and the same year accepted a position as bookkeeper and stenographer in the office of the New Holland Machine Co. His earnest labors and business ability placed him five years later in the position of secretary-treasurer of the company, which position he held until three years ago, when he was selected as the general manager.

Appointments by Portland Cement Association

The Portland Cement Association announces the following appointments in its general office staff effective Oct. 1:

C. R. Ege, Manager, Advertising and Publications Bureau, succeeding H. C. Campbell, resigned.

G. S. Eaton, Assistant Manager, Advertising and Publications Bureau.

W. E. Hart, Manager, Highways and Municipal Bureau, (formerly Highways Bureau).

F. R. McMillan, Manager, Structural and Technical Bureau, (formerly Structural Bureau).

T. J. Harris, Manager, General Educational Bureau.

Mr. Ege is an Associate Member of the American Society of Civil Engineers, has served as treasurer and is now president of the Highway Industries Association. He has been with the association for 10 years, and manager of the Highways Bureau since 1920.

Mr. Eaton has been with the association over 6 years, prior to which was a member of the staff of the Associated General Contractors. He was at first on the staff of the Highways Bureau and has been prominently identified with the publicity and publications features of the association's work.

Mr. Hart is an Associate Member of the American Society of Civil Engineers and is prominent in the affairs of the American Concrete Institute. He has been with the association 9 years and for 4 years has been manager of the Structural Bureau, after having served 3 years as district engineer at Minneapolis.

Mr. McMillan is a member of the American Society of Civil Engineers and has been associate engineer with the Research Laboratory of the association for 2 years, prior to which he was engaged in consulting engineering at Minneapolis. His contributions to engineering literature are widely known, particularly through the American Society of Civil Engineers and the American Concrete Institute.

Mr. Harris has been prominently identified with the advertising activities of the association for 6 years. He has had newspaper experience of note and is identified with numerous organizations in the journalistic field.